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Volume I

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16. ABSTRACT

A study was conducted in Missouri to evaluate the reliability of opacity monitoring data and to facilitate the development and evaluation of QA procedures for opacity CEMS's. The study included opacity CEMS's installed on six coal-fired electric utility generating units at four generating stations, each owned by a different company. The sources were representative of a wide range of monitoring applications and conditions, and were equipped with contemporary opacity monitoring instrumentation. For each station, monitor- and source-specific opacity CEMS QA procedures were developed and CEMS audits were conducted at the beginning of the study. Plant personnel implemented and revised the QA procedures and conducted a performance audit during a 6- to 8-month period. Performance audits were also conducted at the end of the study.

This report presents evaluations both of opacity CEMS reliability (i.e., accuracy, precision, and availability) and of the QA procedures that were used in this study. In summary, appropriate and effective QA procedures can be developed and implemented for a variety of opacity monitoring equipment and applications without imposing an undue burden on the monitor operators. Such procedures are inherently source- and monitor-specific. Reliable opacity monitoring data are obtained when appropriate QA procedures are implemented.

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EXECUTIVE SUMMARY

A field study was conducted at several sources as part of the CEMS Pilot Project in Missouri in order to evaluate the reliability of opacity continuous emission monitoring data and to facilitate the development and evaluation of quality assurance (QA) procedures for opacity continuous emission monitoring systems (CEMS's). The field study included opacity CEMS's installed on six coal-fired electric utility generating units located at four generating stations, each owned by a different utility company. The study sources were selected to be representative of a wide range of monitoring applications and conditions, and were equipped with contemporary opacity monitoring instrumentation provided by the three major opacity CEMS manufacturers.

For each station included in the study, monitor- and source-specific opacity CEMS QA procedures were developed. Opacity CEMS performance and system audits were conducted at each unit at the beginning of the one-year field study. Plant personnel implemented and revised the QA procedures and conducted a performance audit during a 6- to 8-month period. Performance audits were also conducted at the end of the field study.

This report details the results that were obtained from the project and presents evaluations both of opacity CEMS reliability (i.e., accuracy, precision, and availability) and of the effectiveness of the QA procedures that were developed and used in this study. In summary, appropriate and effective QA procedures can be developed and implemented for a variety of opacity monitoring equipment and applications without imposing an undue burden on the monitor operators. Such procedures are inherently source- and monitor-specific. Reliable opacity monitoring data are obtained when appropriate QA procedures are implemented. The use of such QA procedures results in opacity monitoring data of sufficient accuracy, precision, and availability to be used as a reliable indicator of process and control system problems that affect particulate emissions.

1.0 INTRODUCTION

As part of the CEMS Pilot Project in Missouri, a field study was conducted at a limited number of sources in order to evaluate the reliability of opacity continuous emission monitoring data and in order to facilitate the development and evaluation of quality assurance procedures for opacity continuous emission monitoring systems (CEMS's). The field study included opacity CEMS's installed on six coal-fired electric utility generating units located at four generating stations, each of which is owned by a different utility company. The sources included in this study were selected to be representative of a wide range of monitoring applications and conditions, and were equipped with contemporary opacity monitoring instrumentation provided by the three major CEMS manufacturers. This report summarizes the results that were obtained from the project and presents evaluations both of opacity CEMS reliability (i.e., accuracy, precision, and availability) and of the effectiveness of the QA procedures that were developed and used in this study.

As the first step in the field study, information was compiled on the various electric utility steam generating units in Missouri that are required to implement opacity monitoring programs. Basic information included data regarding: the size/capacity of the installation, year on-line, primary and alternative fuel, type of control equipment, and the applicable monitoring regulations and standards (i.e., state regulations for existing sources versus EPA NSPS regulations). More detailed information was also obtained regarding the status of opacity monitoring programs for the various generating units. This information included: (1) the type of monitor installed, (2) monitor installation location(s), (3) the type(s) of data handling system(s), (4) performance specification test results, (5) previous opacity CEMS performance audit results, (6) whether required quarterly excess emission reports were being submitted, and (7) previous CEMS problems and/or excess emissions problems.

Based on the information that was compiled, opacity CEMS's on six generating units at four different generating stations were selected for the study. Some of the important parameters of the four study sources are summarized in Table 1-1. All four of the study sources are pulverized coal-fired electric utility boilers and are equipped with electrostatic precipitators for the control of particulate emissions. All six generating units are subject to opacity monitoring requirements, and all submit quarterly excess emission reports (EER's) to the Missouri Department of Natural Resources (DNR). In addition, the opacity CEMS's on each of the six generating units had been installed at least 1 year prior to this study and had successfully completed the required initial performance specification test.

The differences among the generating stations and units selected for this study are perhaps more revealing than their similarities with respect to the representativeness of the results obtained. The capacities of the various units ranged from 25 MW to 680 MW, thus including both the smallest sources that are subject to opacity monitoring requirements and the second largest unit currently operational in Missouri. The various units were placed in service between 1951 and 1980, and thus reflect changes that have occurred over a 30-year period with respect to power plant design and construction. The study included contemporary opacity monitoring instrumentation manufactured by

TABLE 1-1. OPACITY CEMS STUDY SOURCES

(SIX ELECTRIC UTILITY STEAM GENERATING UNITS
EQUIPPED WITH COLD SIDE ESPs)

COMPANY, STATION	UNIT	OPACITY STANDARD	MONITOR TYPE	DATA RECORDER	MONITORING APPLICATION
Kansas City Power and Light Iatan Station	Unit #1	20% (NSPS)	LSI RM-41	STRIP CHART	Stack-mounted monitor at 300 ft elevation.
St. Joseph Light & Power Co. Lake Road Station	Unit #5	20% (SIP)	CONTRAVES-GOERZ Model 400	STRIP CHART	Stack-mounted monitor.
City Utilities, Springfield James River Station	Unit #4	40% (SIP)	DYNATRON Model 1100	STRIP CHART / DATA LOGGER	Duct-mounted monitor on pressurized boiler.
City Utilities, Springfield James River Station	Unit #5	40% (SIP)	DYNATRON Model 1100	STRIP CHART / DATA LOGGER	Stack-mounted monitor.
Union Electric Company Sioux Station	Unit #1	20% (SIP)	TWO LSI RM41s	COMPUTER DATA LOGGER (STRIP CHARTS)	Dual, duct-mounted monitors with parallel analog & digital combiner system.
Union Electric Company Sioux Station	Unit #2	20% (SIP)	TWO LSI RM41s	COMPUTER DATA LOGGER (STRIP CHARTS)	Dual, duct-mounted monitors with parallel analog & digital combiner system.

Lear Siegler, Inc. (LSI); Dynatron, Inc.; and Contraves Goerz Corporation.[1] The study addressed a variety of opacity CEMS applications typical of those commonly encountered in the electric utility industry, such as: (1) a stack-mounted monitor with very difficult access to the monitoring location (i.e., 300-foot ladder); (2) a stack-mounted monitor with very easy access; (3) identical monitoring equipment on two units at the same station, with one monitor installed in a horizontal, circular, metal duct on a pressurized boiler and the other monitor installed in the masonry exhaust stack of a balanced draft boiler; and (4) identical opacity CEMS's installed on two generating units where each system is composed of two transmissometers (one on each of a pair of twin ducts downstream of the ESP's) and both analog and digital systems for determining the combined stack exit opacity for the single exhaust stack of each generating unit. Two of the stations and four of the units had opacity CEMS's with data loggers or computerized data handling systems. The other units relied solely on the use of strip chart recorders. In addition to the above differences, which were apparent at the outset of the study, significant differences among the various sources were observed as the study progressed with respect to (1) the management and organizational structure of the personnel involved with the opacity monitoring program, (2) the relationship between station personnel and corporate representatives, and (3) the presence and impact of union agreements that affected the operation and/or maintenance of the opacity CEMS's.

For each of the stations selected for the study, preliminary draft opacity CEMS QA procedures were developed. The development of these preliminary procedures was based on (1) the design of the monitoring system, (2) information from the operator's manuals provided by the monitor manufacturers, and (3) previous experience in testing and auditing similar monitors. An initial audit of each of the six opacity CEMS's was performed. Each initial audit included a systems audit (i.e., a qualitative evaluation of operation, maintenance, and record keeping practices) and a performance audit (i.e., a quantitative evaluation of CEMS accuracy and precision). Based on information gained from the initial audits and comments provided by personnel from the participating sources, the preliminary QA procedures were revised. These revisions primarily addressed (1) source-specific factors that were unknown prior to the initial audit, (2) inclusion of existing routine maintenance procedures in the draft periodic QA procedures, and (3) modification of the QA procedures to make them compatible with the management and organizational structure of each of the participating sources. For each source, the QA procedures included: (1) relatively simple checks to be performed on a daily basis from the monitor control unit location (i.e., the boiler control room), (2) periodic QA checks to be performed (usually on a monthly basis) both at the actual monitoring location and at the control unit, and (3) generalized corrective action procedures to be used when daily QA check and/or periodic QA check control limits were exceeded or when repairs to the opacity CEMS were necessary.

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[1] During this project, Thermo Electron, Inc. acquired the sole rights to sell the opacity monitor previously manufactured and sold by Contraves Goerz. The monitor is now referred to as a TECO Model 400; however, throughout this report, the monitor is referenced as a Contraves Goerz Model 400 opacity CEMS.

After agreement with source representatives was obtained on all of the detailed step-by-step QA procedures, station personnel implemented these procedures for approximately 6 to 8 months. The QA documentation was then reviewed by the project team, and recommendations for revisions to the QA procedures were made. In most cases, suggestions were made to simplify the QA procedures based on analysis of the data that had already been obtained.

Personnel from each station were asked to conduct a performance audit of the CEMS('s) included in the study using audit equipment supplied by the project team and procedures similar to those used in the initial performance audit of the opacity CEMS('s). The purposes for requesting the source self audits were: (1) to quantify further the accuracy and precision of the opacity CEMS data and (2) to determine if source personnel could conduct such audits with little or no training. Each station conducted an audit of their opacity CEMS('s) and provided copies of the audit results to the project team.

The four study sources continued the implementation of the opacity CEMS QA procedures to varying degrees for the duration of the approximate 1-year study. The field study was concluded at each station when the project team completed the final performance audit of the CEMS('s) and interviewed station personnel to obtain additional comments regarding the reliability of the opacity monitoring equipment and the appropriateness/effectiveness of the QA procedures.

In addition to the QA documentation provided by each of the study sources and the results of the performance audits that were conducted, data and information on opacity CEMS performance were also obtained from the review of EER's that were submitted to the Missouri DNR. These data were used to supplement and to compare with the QA documentation. (An evaluation of monitor performance based on data for all electric utility sources in Missouri submitting quarterly reports to the DNR is contained in "An Analysis of Opacity CEMS Downtime in Excess Emission Reports: Opacity CEM Pilot Project Report" (May 1986).

It is emphasized that two of the major technical objectives of the opacity CEM Pilot Project field study were to determine (1) whether appropriate and effective opacity CEMS QA procedures could be developed and implemented for a variety of opacity monitoring equipment and applications without imposing an undue burden on the monitor operators, and (2) whether reliable opacity monitoring data are obtained when such QA procedures are used. For this project, the quality of opacity CEMS data was considered adequate when the data were of sufficient accuracy, precision, and availability to provide a reliable indication of process and control system problems for both source representatives and control agency personnel. Thus, this study did not attempt to identify or to define the "ideal" or "absolute minimum" QA plan. Instead, the study attempted to develop, for a number of monitor- and source-specific situations, relatively simple, cost effective QA procedures. It was intended that the process of developing these procedures and the flexibility of the approach that was used would provide examples that could be easily adapted for other sources and situations. An example of this approach is provided by the QA control limits used in this study. These limits reflect a rough balance between what is achievable and what is necessary to ensure that the opacity monitoring data are reasonably reliable. As a specific example, the zero and span check control limits varied slightly among the four study sources (due to monitor- and source-specific technical considerations as well as to the opinions of monitor operators as to what tolerance was appropriate), and differed from the currently applicable EPA requirements. However, these differences in specific QA control limits are not considered important, since the QA control limits can be easily adjusted to whatever level is appropriate for any particular case. Again, the specific QA control limits should be established at a level (1) that ensures monitoring data will be of sufficient accuracy and precision to facilitate the intended use of the data, and (2) that takes into account the level of performance that can be achieved when the opacity CEMS is properly operated and maintained.

Section 2.0 of this report presents the overall findings and conclusions that were obtained from the Missouri Opacity CEMS Pilot Project relative to opacity CEMS reliability and to the evaluation of QA procedures. Sections 3.0 through 6.0 present relevant background information, a detailed summary and discussion of the data and results obtained, and the conclusions that were developed for each of the study sources. Appendices A through D include copies of source-specific QA procedures, daily QA check summaries, and the data and calculations resulting from the source self audits. Appendix E includes a report describing the calibration procedures and results for the neutral density filters used in the performance audits of the opacity CEMS's during the project.

2.0 CONCLUSIONS

This section presents the overall conclusions developed from the Missouri Opacity CEMS Pilot Project with respect to opacity CEMS reliability (i.e., accuracy, precision, and availability) and to the effectiveness of opacity CEMS quality assurance procedures. These conclusions are supported by the information included in Sections 3.0 through 6.0, which present the results obtained at each of the four study sources.

1. Most properly operated and maintained opacity CEMS's can achieve high levels of monitor availability (i.e., greater than 95% of the hours per calendar quarter), regardless of whether a single monitor CEMS or a dual monitor/combiner system CEMS is used.

2. Monitor availability can be improved at sources using computerized data handling systems if properly calibrated chart recorders are used as back-up recording devices during computer system outages.

3. The accuracy and precision of opacity CEMS data relative to zero (or low range) and span checks can be maintained within ± 2.5% opacity with very few calibration adjustments per year for CEMS's equipped with chart recorders, data loggers, or computerized data handling systems.

4. The accuracy of opacity CEMS data can be consistently maintained within ± 3% opacity relative to audit filter values used in calibration error checks for opacity CEMS's equipped with chart recorders, data loggers, or computerized data handling systems.

5. On-stack, clear-path zero checks (i.e., zero alignment tests) cannot be performed for most sources because of the presence of significant residual opacity during source outages.

6. Off-stack, clear-path zero checks can be performed; however, some CEMS operators contend that such tests do not enhance the accuracy of the opacity monitoring data. CEMS operators did not attempt the alternate zero alignment procedures that were recommended during this project, even though these procedures can be performed at the monitoring location.

7. Appropriate and effective opacity CEMS QA procedures are inherently monitor- and source-specific. In addition, the designation of responsibilities for particular QA activities must be consistent with the management and organizational structure for the personnel at the power plant.

8. It has been demonstrated that opacity CEMS QA procedures can be developed and successfully implemented where only a few personnel are responsible for the opacity monitoring program, or where many personnel share responsibility for the opacity monitoring program. The need for clearly written QA procedures and careful, complete documentation of QA check results increases in direct proportion to the number of people involved in the opacity monitoring program.

9. Some monitor system fault indicators are useful in the identification of monitor operational problems.

10. Daily QA checks of opacity CEMS's provide both timely identification of problems and adequate records from which changes in monitor performance and/or chronic monitoring problems can be identified. Such checks may include (a) checks of fault indicators, (b) determination of whether the opacity CEMS (including the data recording system) is operating within applicable zero and span check control limits, and (c) checks of other readily accessible monitor-specific parameters.

11. Adequate and effective checks for most opacity CEMS's can be completed from the monitor control unit (usually located in the boiler control room), and typically require less than 5 minutes per monitor per day to perform.

12. Optimization of the parameters to be included in daily QA checks is facilitated by recording values for all parameters in question for some baseline period, and subsequently selecting an appropriate frequency for performing the checks based on observed monitor performance (i.e., the stability of the recorded values over time).

13. Periodic QA procedures provide for (a) the identification of problems that may otherwise be overlooked, (b) verification of proper operational status of parameters not included in the routine zero/span checks or daily checks, and (c) a means by which the optimum frequency for various activities included in the periodic QA procedures can be determined. Periodic QA procedures may include (a) zero and span checks for all data display devices, (b) checks of optical alignment, (c) checks for dust accumulation on, and cleaning of, exposed optical surfaces, (d) checks of auxiliary monitoring parameters (e.g., reference currents/voltages, etc.), and (e) performance of preventive maintenance procedures recommended by the manufacturer.

14. It has been demonstrated that effective QA procedures may involve the performance of periodic QA checks at frequencies ranging from once per month to once every four months. The time required to perform such tests typically ranges from 2 to 8 hours per periodic QA check. Both the frequency of performing such checks and the time required to complete them will vary depending on monitor- and source-specific factors.

15. Properly conducted performance audits provide a valid means of assessing monitor performance; however, they do not provide a check of the accuracy of the zero adjustment status.

16. In order to provide a representative indication of actual monitor performance, audit procedures published previously (i.e., "Performance Audit Procedures for Opacity Monitors," EPA-340/1-83-010) should be modified to account for source-specific factors (see "Opacity CEMS Audit Procedures Guidelines: Opacity CEMS Pilot Project Draft Report," March 1985).

17. Modified performance audit procedures must be used for dual CEMS/combiner applications in order to obtain a representative indication of monitor performance (see "Opacity CEMS Audit Procedures Guidelines: Opacity CEMS Pilot Project Draft Report," March 1985).

18. Most electric utility generating stations have personnel capable of conducting opacity CEMS performance audits with little or no formal training, provided that they receive clearly written audit procedures with examples of completed data sheets and calculations.

19. Most electric utility generating stations with opacity CEMS's that have been installed for at least 1 year have personnel who thoroughly understand how the monitor works and who are capable of performing virtually all necessary repairs and/or adjustments to maintain the opacity CEMS within the applicable control limits.

In summary, appropriate and effective QA procedures can be developed and implemented for a variety of opacity monitoring equipment and applications without imposing an undue burden on the monitor operators. Such procedures are inherently source- and monitor-specific. Reliable opacity monitoring data are obtained when appropriate QA procedures are implemented. The use of such QA procedures results in opacity monitoring data of sufficient accuracy, precision, and availability to be used as a reliable indicator of process and control system problems that affect particulate emissions.

3.0 CITY UTILITIES, JAMES RIVER STATION, UNITS NO. 4 AND 5

This section provides relevant background information and a summary and discussion of results obtained from both (1) the implementation of quality assurance procedures and (2) the performance audits of the installed opacity CEMS's at City Utilites' James River Station, Units No. 4 and 5. An overview of the field study conducted for these two units is provided in Figures 3-1 and 3-2.

3.1 SOURCE AND MONITOR DESCRIPTIONS

3.1.1 Source Description

Three coal-fired electric utility steam generating units are currently operational at the City Utilities James River Station. All three units operate independently, and each unit is equipped with an electrostatic precipitator (ESP) and an exhaust stack. Units No. 3, 4, and 5 are rated at 44, 60, and 105 MW capacity, respectively. The coal used to fuel all three units is mined in Kansas and Oklahoma and typically ranges from 2% to 3% sulfur. All three units are subject to a Missouri opacity limit of 40%. As shown in Figures 3-1 and 3-2, Units No. 4 and 5 operated intermittently during the field study.

3.1.2 Monitor Description

Units No. 3, 4, and 5 are each equipped with a separate Dynatron Model 1100 opacity monitoring system; however, only the performance of the Units No. 4 and 5 monitors were evaluated during this project. Units No. 4 and 5 represent different opacity monitoring applications, even though identical instrumentation is used for the two units. Unit No. 4 is a pressurized boiler, and the opacity monitor is located in a metal, horizontal, circular duct between the ESP and the stack (see Figure 3-3). Unit No. 5 is a balanced draft boiler; the opacity monitor is installed in the masonry exhaust stack (see Figure 3-4).

Each of the Dynatron Model 1100 opacity monitors utilized at the James River Station consists of a single transmissometer (transceiver and reflector) and a monitor control unit. Plastic weather covers with tight fitting seals and internally mounted purge air systems are provided at each of the transceiver and reflector installation locations. Both transceivers are equipped with optical alignment sights. A single, 3-pen strip chart recorder and a time-shared data logger are used to record data for all three monitors. All three monitor control units, the strip chart recorder, and the data logger are mounted together in the boiler control room. Six-minute average effluent opacity levels are displayed by the strip chart recorder; the data logger provides a printed record of calibration data and effluent opacity values greater than 40% opacity.

3.2 INITIAL AUDIT

Initial audits of the opacity CEMS's installed at the James River Station Units No. 4 and 5 were performed on April 12, 1983. The audits included (1) a visual evaluation of the monitor installation location, (2) a systems audit

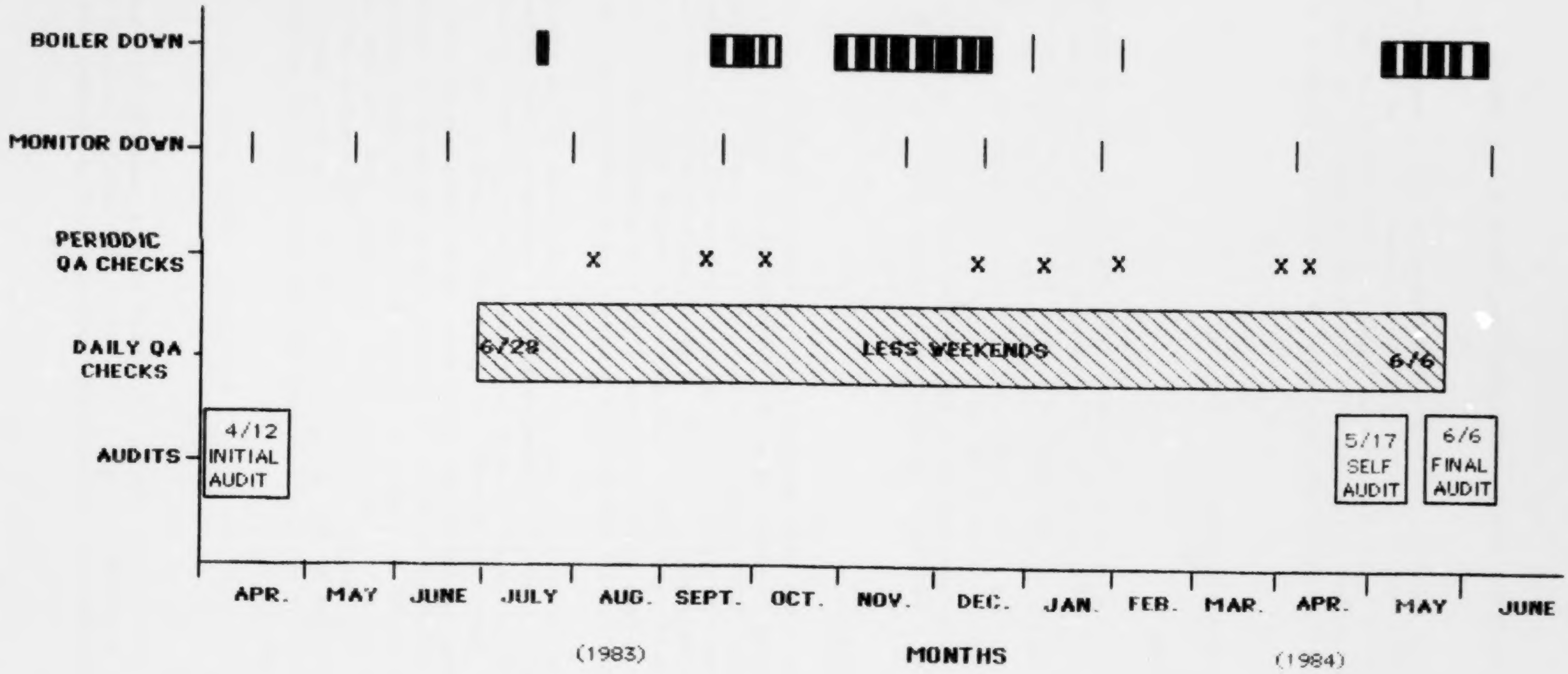


FIGURE 3-1. CITY UTILITIES, JAMES RIVER UNIT NO. 4 OPACITY CEMS PROJECT

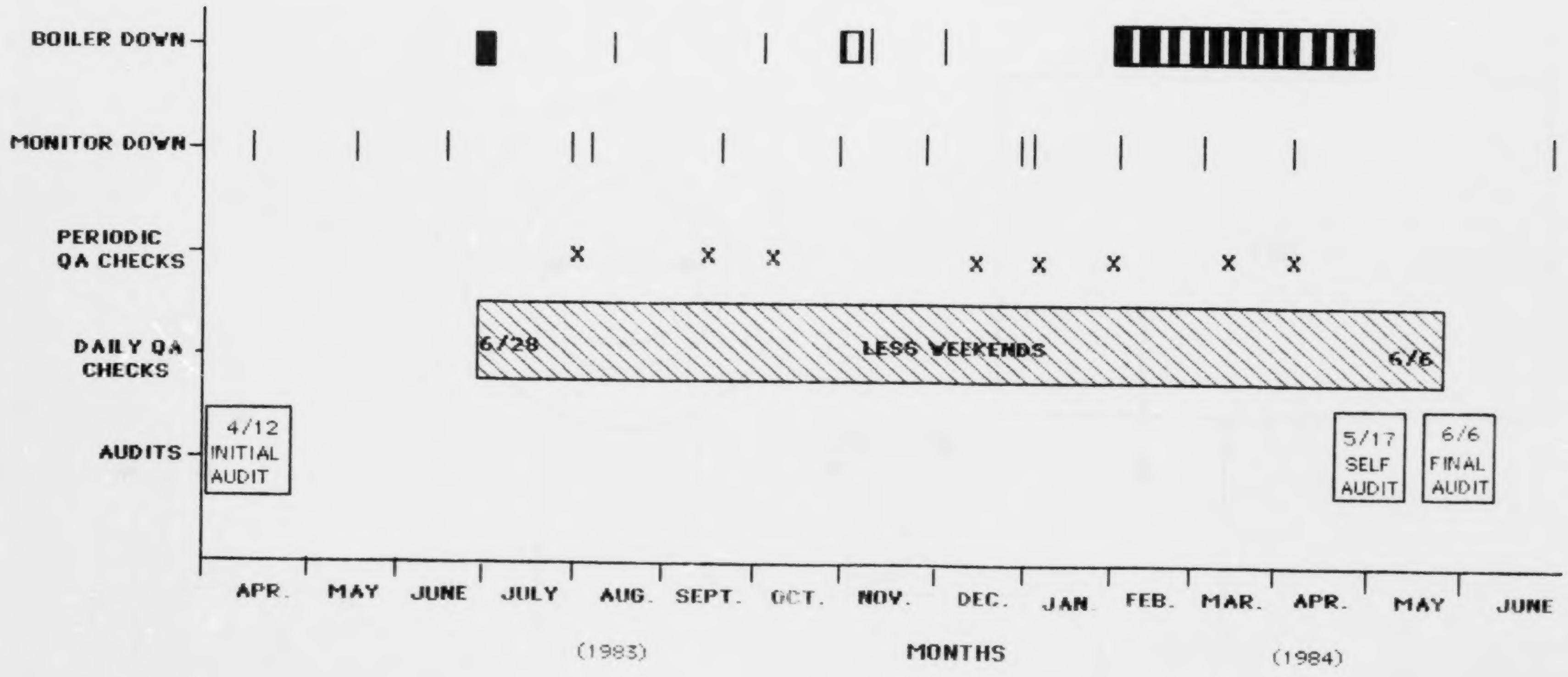


FIGURE 3-2. CITY UTILITIES, JAMES RIVER UNIT NO. 5: OPACITY CEMS PROJECT

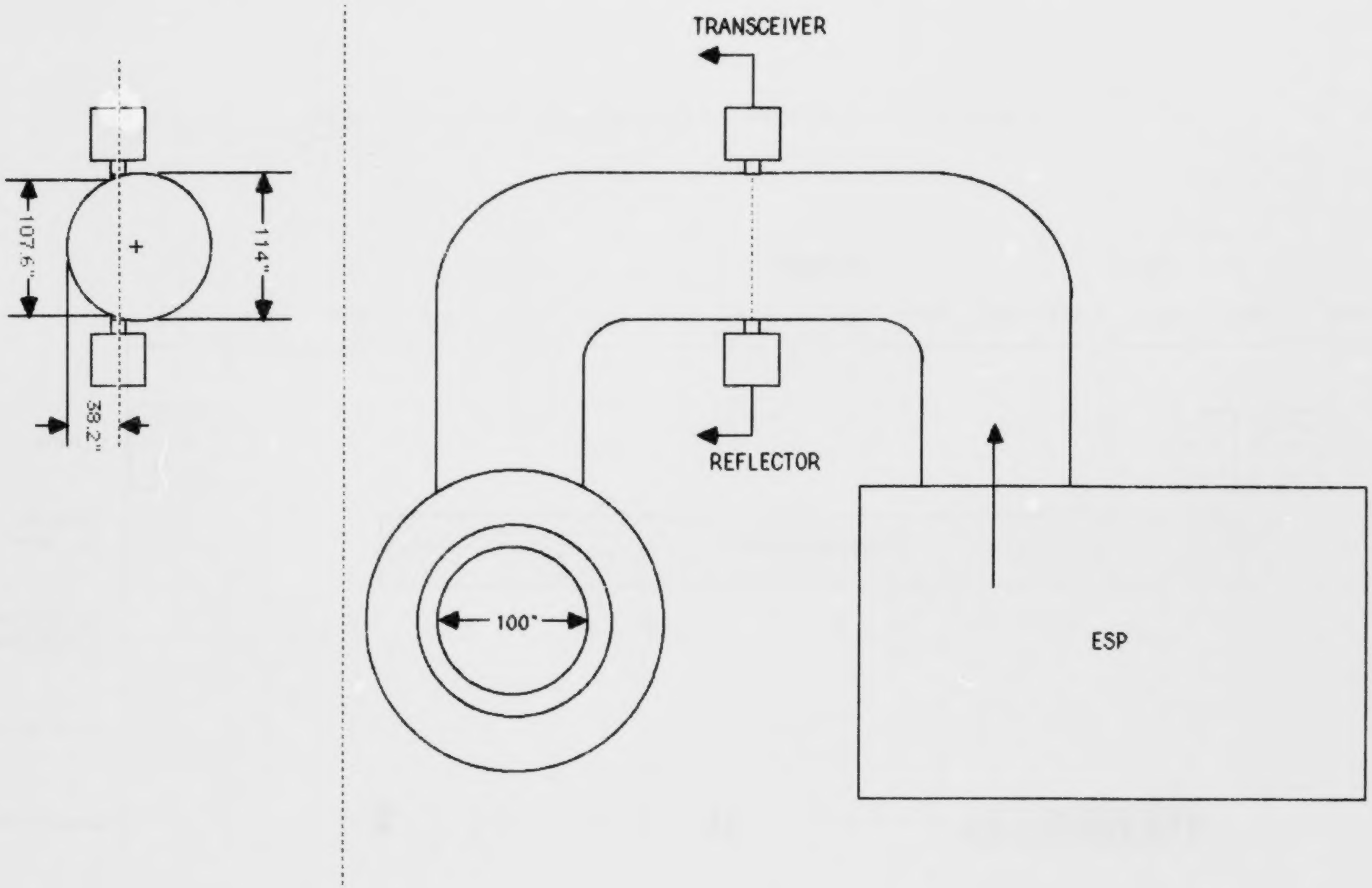

107.6"
114"
38.2"
TRANSCEIVER
REFLECTOR
100"
ESP

FIGURE 3-3. UNIT NO. 4 OPACITY MONITORING LOCATION

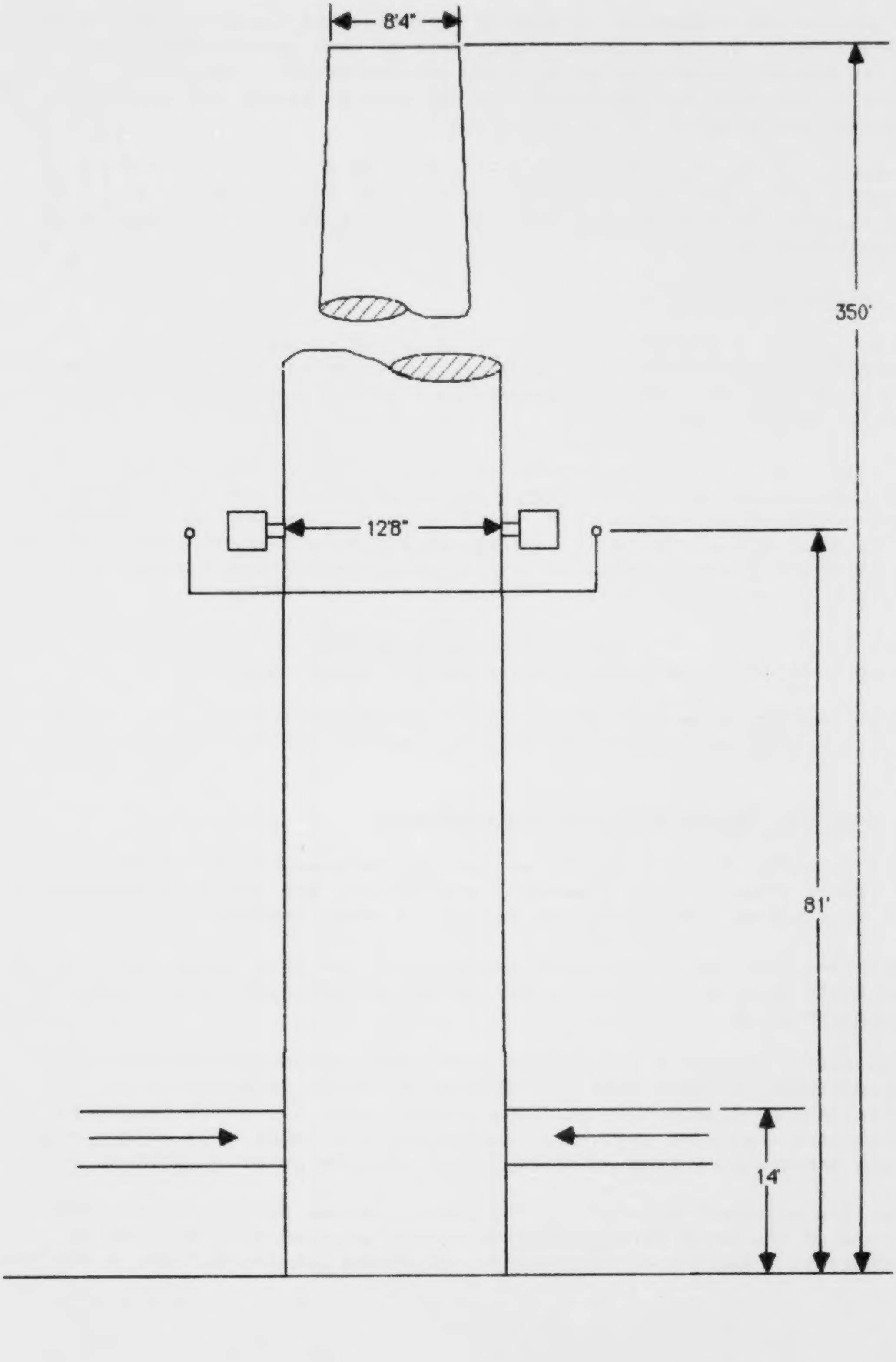

8'4"
350'
12'8"
81'
14'

FIGURE 3-4. UNIT NO. 5 OPACITY MONITORING LOCATION

(i.e., a qualitative evaluation of monitor operation, maintenance, and record keeping practices), and (3) a performance audit of each opacity CEMS (i.e., a quantitative evaluation of monitor accuracy and precision). Detailed discussions of the findings and results of the initial audits are included in the April 1983 audit report for this station.

The results of the initial performance audits of the Units No. 4 and 5 opacity CEMS's are summarized in Tables 3-1 and 3-2, respectively. The following conclusions were derived from the initial audits of the James River opacity monitoring systems.

Monitor Installation Location

1. The Unit No. 5 monitoring system is installed in accordance with Performance Specification 1, Appendix B, 40 CFR 60, and the measurement location provides opacity measurements that are representative of the entire effluent stream.
2. The Unit No. 4 monitoring system is installed in accordance with Performance Specification 1, Appendix B, 40 CFR 60, and is installed at the best available monitoring location, since no access nor ports are available in the Unit No. 4 masonry stack. It is believed that the measurement location provides opacity measurements that are representative of the entire effluent stream.
3. The Units No. 4 and 5 opacity monitoring systems are not currently subject to any known adverse environmental conditions.
4. The excellent access to the installed transmissometers on Units No. 4 and 5 facilitates performance of necessary monitor maintenance activities.

Monitor Operation, Maintenance, and Record Keeping

1. The Units No. 4 and 5 opacity monitoring instrumentation operates reliably. High levels of monitor availability are achieved; adjustments of zero and/or span values are rarely, if ever, required.
2. Problems with the inconsistent operation of the data logger timer are due to short term fluctuations (i.e., spikes and glitches) in the power supply voltage.
3. Successful solutions for several previously encountered monitor operational problems have been devised by source personnel (e.g., fabrication of prototype Teflon/stainless steel transition pieces to eliminate corrosion problems, fabrication of a rubber shroud to prevent rain water runoff from being aspirated into the purge air system, etc.).
4. Monitor alignment problems during boiler outages due to thermal contractions of the metal duct at the monitoring location will continue to necessitate additional maintenance activities for the Unit No. 4 monitor.

TABLE 3-1. SUMMARY OF PERFORMANCE AUDIT RESULTS

CITY UTILITIES, JAMES RIVER STATION, UNIT NO. 4
DYNATRON MODEL 1100 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Lamp	Off	Off
Window	Off	Off
Air Flow	Off	Off
Stack Exit Correlation Error	0% (Assumed)	± 2%
Panel Meter Correction Factor	1.00	0.98 to 1.02
Internal Zero Error	0.5% Opacity	± 2% Opacity
Internal Span Error	0.5% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	1% Opacity	≤ 2% Opacity
Reflector Window	0% Opacity	≤ 2% Opacity
Total	1% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (32.1% Opacity)	-0.1%*	0.6%*	≤ 3%
Mid Range (72.8% Opacity)	-4.4%	4.9%	≤ 3%
High Range (88.1% Opacity)	-0.7%	1.3%	≤ 3%

* Results calcuated from first four measurements, since effluent opacity fluctuations affected the last filter measurement result.

TABLE 3-2. SUMMARY OF PERFORMANCE AUDIT RESULTS

CITY UTILITIES, JAMES RIVER STATION, UNIT NO. 5
DYNATRON MODEL 1100 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Lamp	Off	Off
Window	Off	Off
Air Flow	Off	Off
Stack Exit Correlation Error	0% (Assumed)	± 2%
Panel Meter Correction Factor	1.00	0.98 to 1.02
Internal Zero Error	-1.0% Opacity	± 2% Opacity
Internal Span Error	-0.5% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	0% Opacity	≤ 2% Opacity
Reflector Window	-1% Opacity	≤ 2% Opacity
Total	-1% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (19.2% Opacity)	0.2%	2.0%	≤ 3%
Mid Range (48.5% Opacity)	-1.9%	2.7%	≤ 3%
High Range (65.8% Opacity)	0.2%	0.5%	≤ 3%

Monitor Performance

1. The Unit No. 5 opacity montoring system was found to exhibit acceptable performance for all criteria evaluated during the performance audit.

2. The Unit No. 4 opacity monitoring system was found to exhibit acceptable performance for all criteria evaluated during the performance audit except for the mid range calibration error. Taking into consideration both the magnitude of the error for the mid range filter and the opacity level at which the mid range test was performed, it is expected that the observed problem will not affect the identification of periods of excesss emissions.

3.3 QUALITY ASSURANCE PROCEDURES

Draft quality assurance procedures were developed for the James River Units No. 4 and 5 opacity CEMS's. The QA procedures consisted of daily checks, periodic QA procedures, and criteria and general procedures for use in performing corrective action for the opacity CEMS's. During the initial audits of the opacity CEMS's, additional information was obtained which allowed for revision of the draft QA procedures. (A copy of the QA procedures utilized during the study is included in Appendix A of this report.) Implementation of the QA procedures began on June 28, 1983. Based on a review of the QA data obtained during the first 9 months of the field study, recommendations for revisions to the QA procedures were developed. The following section provides a brief description of the QA procedures, a summary of the QA data, and a discussion of the results of implementing the QA program.

3.3.1 Daily QA Checks

The daily check procedures involve only simple checks of monitor operation that can be performed at the monitor control unit. The purpose of these checks is to determine whether the opacity CEMS is apparently operating properly or if corrective action is necessary. For the Dynatron opacity CEMS's at the James River Station, these procedures involved: (1) a check of whether fault lamps were illuminated, (2) zero and span checks for both the strip chart recorder and the data logger, and (3) a check of the data logger timer. The time required to perform the QA checks, as well as both the boiler and monitor downtime during the previous 24-hour period, were also noted on the daily log. An example daily log is shown in Figure 3-5. As was agreed at the beginning of the study, the daily logs were not filled out on Saturdays and Sundays because of the reduced number of personnel at the station during weekend shifts.

Summaries of all of the daily QA check results from June 28, 1983 until June 6, 1984 for both Units No. 4 and 5 are included in Appendix A of this report. These summaries contain all of the information recorded on the daily logs in a condensed format. With very few exceptions, the daily log sheets were completed each day, including those periods during which the boiler was not operating. (Extended boiler outages occurred for both Units No. 4 and 5 during the study.) The same individual performed almost all of the daily checks of both monitoring systems during the 1-year study. Only two other individuals performed daily checks of either of the opacity CEMS's during the study.

Opacity Monitoring System

DAILY LOG

CITY UTILITIES JAMES RIVER STATION UNIT:__________

I. GENERAL INFORMATION

Name:______ ___________ Date: ___________ Time Start: __________

Time Complete:__________

Hours Boiler Down: ____________ Hours Monitor Down: __________

II. FAULT LAMPS

FAULT LAMPS ON?	NO	YES
Lamp		
Window		
Air Flow		

III. ZERO/SPAN CHECK DATA

Chart Recorder, Zero Value:______________ Span Value:______________

Data Logger, Zero Value: ______________ Span Value:______________

	NO	YES
Does Zero Value exceed acceptable limits of ± 2% opacity?		
Does Span Value exceed acceptable limits of ± 2% opacity?		

	Correct	Incorrect
Data Logger Timer		

IF YES ANSWERS ARE INDICATED FOR ANY OF THE ABOVE QUESTIONS, CORRECTIVE ACTION SHOULD BE INITIATED AS SOON AS POSSIBLE.

IV. COMMENTS:

FIGURE 3-5. EXAMPLE OPACITY CEMS DAILY LOG: CITY UTILITIES, JAMES RIVER STATION

Fault Lamp Indicators

Each of the Dynatron Model 1100 opacity monitoring systems are equipped with three fault lamps which, when illuminated, indicate an operational problem with the monitor. These fault lamps are:

(1) LAMP - Indicates when lamp reference voltage is outside of acceptable range.

(2) WINDOW - Indicates when dust accumulation on the transceiver optics exceeds acceptable range.

(3) AIR FLOW - Indicates problem with air purge system.

The daily check results indicate that no fault lamps were illuminated at any time during the 1-year study for the Unit No. 4 opacity CEMS.

The daily check results for the Unit No. 5 opacity CEMS indicate that no fault lamps were illuminated at any time during the 1-year study except for one instance when the "LAMP" fault was activated. This fault condition was first observed during the periodic QA check performed on 8/4/83, and subsequently appeared on the daily log records for 8/5 and 8/8/83 while corrective action was being performed. Corrective action was completed on 8/9/83; the fault condition was resolved at that time and did not reappear during the remainder of the study.

Although the "WINDOW" fault was never illuminated for either the Unit No. 4 or No. 5 monitors, several instances were observed when the apparent effluent opacity was significantly reduced as a result of cleaning of the transceiver window. Notes on the daily check logs indicate that cleaning of the transmissometer windows on July 28, 1983 reduced the apparent effluent opacity by 11% opacity and 8% opacity for Units No. 4 and 5, respectively. (The daily logs also indicate that the Unit No. 5 windows were cleaned on December 2, but no estimate of the effect of this action on the effluent opacity measurements is provided.) For Unit No. 4, the data recorded during the periodic QA checks indicate that the apparent effluent opacity was reduced by 13% (9/15/83), 5% (1/9/84), 5% (2/1/84), and 8% opacity (3/30/84) as a result of cleaning of the transceiver window. For Unit No. 5, the periodic QA check data show reductions in the apparent effluent opacity of 5% (9/15/83), 3% (2/1/84), and 3% opacity (3/30/84) as a result of cleaning of the transceiver window. Although the method used to estimate the impact of window cleaning during the QA checks is inexact, the results that were obtained suggest that the "WINDOW" fault detector does not necessarily provide an effective indication of when the windows need to be cleaned. This problem may result from either (1) an inherent problem in the design of the "WINDOW" fault system, or (2) an improper setting of the "WINDOW" fault sensitivity adjustment.

"Zero" Checks

For Dynatron opacity monitors, a check of each of the monitoring systems' responses in the low opacity range (e.g., 8-10% opacity) is performed once per day in place of a zero opacity check. The monitors' responses to this check, as indicated by both the data logger printout and the strip chart, were recorded on the daily log. According to the draft QA procedures, adjustment of the monitor was to be performed when the monitor response exceeded ± 2.0% opacity relative to the correct value for the low range check.

For the Unit No. 4 opacity CEMS, the correct value for the "zero" check is 9% opacity. During the 1-year study, there were no exceedances of the ± 2% opacity "zero drift" limit indicated by the responses recorded from either the chart recorder or data logger. The ± 2% opacity zero drift limit was equalled but not exceeded on three occasions as indicated by the chart recorder responses, and on only one occasion as indicated by the data logger. In the vast majority of the checks, the low range check responses indicated by the chart recorder and the data logger agreed within ± 1% opacity.

For the Unit No. 5 opacity CEMS, the correct value for the "zero" check is 10% opacity. During the 1-year study, there were no exceedances of the ± 2% opacity "zero" drift limit indicated by the responses recorded from either the chart recorder or the data logger except on 2/9/84, when the chart recorder indicated a "0" value for the low range check, and on 2/10/84, when the data logger recorded the same value for both the "low" range and span check responses. In both of these cases, the alternate recording device indicated that the low range response was within ± 2% opacity.

There were 17 occasions when the ± 2% "zero" drift limit was equalled but not exceeded by either or both the chart recorder and data logger responses. All but one of these occurrences were during the same 50-day period (7/10/83 to 8/18/83). In general, the low range check responses indicated by the chart recorder and the data logger agreed within ± 1% opacity most of the time, and within ± 2% opacity nearly all of the time.

The same data logger is used for both Units No. 4 and 5. The daily QA checks indicate many instances when the data logger failed to record the low range check response. In most of these cases, the calibration checks were initiated manually by the operator. The temporary malfunction of the data logger/timer circuits are attributed to supply voltage transients (i.e., peaks and glitches) at the James River Station.

Span Checks

Span checks of the Units No. 4 and 5 opacity monitors were performed at least once daily during the study using the internal calibration devices contained in the Model 1100 transceivers. The opacity CEMS's span check responses indicated by both the chart recorder and the data logger were recorded on the daily log. According to the draft QA procedures, corrective action was to be initiated when the monitor responses exceeded ± 2% opacity relative to the correct value (i.e., 61% and 50% opacity for Units No. 4 and 5, respectively).

For the Unit No. 4 opacity CEMS, there were no exceedances of the ± 2% opacity span limit during the 1-year study indicated by either the chart recorder responses or the data logger responses. In fact, all of the chart recorder responses and all except eight of the data logger values were within ± 1% opacity of the correct span value. The eight data logger responses that exceeded ± 1% opacity were all 63% opacity (i.e., 2% opacity), indicating a slight positive bias in the data logger calibration relative to the Unit No. 4 chart recorder calibration.

For the Unit No. 5 opacity CEMS, there were no exceedances of the ± 2% opacity span drift limit during the 1-year study indicated by the data logger responses. In fact, all of the data logger responses were within ± 1% opacity.

One exceedance of the span drift limit was observed in the chart recorder response on 2/9/84, when a value of 37% opacity was recorded for the span check. The daily log acknowledged that the chart recorder response differed from the data logger response; however, the problem was apparently resolved before the span check was conducted the following day. Other than the above problem, all except four of the chart recorder span check responses were within ± 1% opacity. The four chart recorder responses that exceeded ± 1% opacity were all 48% opacity (i.e., - 2% opacity), indicating a slight negative bias in the chart recorder calibration relative to the data logger calibration.

Time Required for Daily Checks

The time required to perform the daily checks of the James River Station opacity monitoring systems is recorded on the daily log sheets. During the 1-year field study, three different individuals performed all of the daily checks of the Units No. 4 and 5 monitoring systems. Exclusive of the first week of the project, the time required to perform the daily check procedures was almost always 2 minutes per day per monitor. For a relatively small number of cases, 3 to 6 minutes were necessary to complete the daily checks.

3.3.2 Periodic QA Checks

The periodic QA procedures provide for checks of monitoring system components and operational status that are unfeasible, impractical, or unnecessary on a daily basis. The periodic QA checks were intended to be performed in conjunction with the opacity CEMS routine maintenance program that is performed monthly at the James River Station. The periodic QA check procedures included: (1) "zero"/span checks of the panel meter, chart recorder, and data logger, (2) a check of the lamp reference voltage, (3) a check of optical alignment of the transmissometer components, and (4) a determination of the apparent dust accumulation on the transmissometer windows.

A total of eight periodic QA checks for each monitor were performed on an approximate monthly basis. All of the periodic QA checks were performed by the same person; this individual did not perform any of the daily checks of the opacity CEMS's. Summaries of the periodic QA check results for Units No. 4 and 5 are shown in Tables 3-3 and 3-4, respectively. The periodic QA results support the following findings:

- The time required to perform the periodic checks ranged from 15 to 45 minutes per monitor. A significant amount of additional time was needed to complete corrective action for a problem identified during the first periodic QA check of the Unit No. 5 opacity CEMS.
- The low range and span check responses provided by the panel meter, chart recorder, and data logger during the periodic QA checks were all within ± 2% opacity of the correct values for both monitors. The differences among the responses of the three recording devices were consistently less than 2% opacity for all of the low range and span checks for both monitors. No "zero" or span adjustments were made for either the Unit No. 4 or No. 5 opacity CEMS's during the 1-year field study.

TABLE 3-3
PERIODIC QA CHECK RESULTS
CITY UTILITIES, JAMES RIVER STATION
BOILER #4, MONITOR #2

DATE	TIME REQ. (MIN.)	LOW RANGE ERROR (% OPACITY)			HIGH RANGE ERROR (% OPACITY)			LAMP VOLTAGE (VOLTS)	ALIGNMENT	APPARENT DUST ACCUMULATION (% OPACITY)			
		METER	CHART	LOGGER	METER	CHART	LOGGER			REFLECTOR	TRANSCEIVER	TOTAL	6-MIN. AVG.
8/4/83	45	0%	0%	-1%	0%	0%	+1%	6.43	O.K.	0%	1%	1%	3%
9/15/83(1)	--	0%	0%	-1%	0%	0%	0%	--	O.K.	1%	13%	14%	14%
10/7/83	20	0%	0%	-1%	0%	0%	+1%	6.63	O.K.	1%	1%	2%	2%
12/12/83(2)	15	0%	+1%	-1%	0%	+1%	+1%	6.73	O.K.	0%	0%	0%	0%
1/9/84(3)	30	0%	0%	0%	0%	+0.5%	+1%	6.75	O.K.	4%	5%	9%	11%
2/1/84	20	0%	+1%	0%	+1%	+1%	+2%	6.70	O.K.	4%	5%	9%	12%
3/30/84	45	0%	+0.5%	-1%	+1%	+1%	+1%	6.65	O.K.	6%	8%	14%	15%
4/9/84	45	0%	+0.5%	-1%	+1%	+0.5%	+1%	6.67	O.K.	0%	2%	2%	2%

NOTES:

(1) "Clear" lamp burnt out.
(2) Unit off-line.
(3) Replaced recorder pen and lamp in "early warning" indicator.

TABLE 3-4
PERIODIC QA CHECK RESULTS
CITY UTILITIES, JAMES RIVER STATION
BOILER #5, MONITOR #1

DATE	TIME REQ. (MIN.)	LOW RANGE ERROR (% OPACITY)			HIGH RANGE ERROR (% OPACITY)			LAMP VOLTAGE (VOLTS)	ALIGNMENT	APPARENT DUST ACCUMULATION (% OPACITY)			
		METER	CHART	LOGGER	METER	CHART	LOGGER			REFLECTOR	TRANSCEIVER	TOTAL	6-MIN. AVG.
8/4/83(1)	45	-1%	-1.5%	-1%	-1%	-1%	0%	4.34	O.K.	0%	0%	0%	0.5%
9/15/83	--	+1%	0%	+1%	0%	-1%	0%	--	O.K.	2%	5%	7%	8%
10/7/83	20	0%	0%	+1%	0%	-0.5%	0%	6.35	O.K.	1%	0%	1%	2%
12/12/83	15	0%	0%	0%	0%	-0.5%	0%	6.31	O.K.	0%	0%	0%	-3%
1/9/84(2)	30	0%	0%	+1%	0%	-1%	+1%	6.36	O.K.	1%	1%	2%	0%
2/1/84(3)	185	0%	0%	+1%	0%	-1%	+1%	6.31	O.K.	4%	3%	7%	12%
3/30/84(4)	45	0%	0%	0%	0%	-0.5%	0%	6.28	O.K.	5%	3%	8%	8%
4/9/84(5)	45	0%	0%	0%	0%	0%	0%	6.26	O.K.	0%	0%	0%	0%

NOTES:

(1) Lamp light on; could not adjust lamp voltage above 4.36 volts. (Corrective action performed 8/5 - 9/83; readjust lamp power supply and performed system set-up procedure - 36 manhours total.)
(2) Replaced clear lamp in panel indicator.
(3) Unit #5 off-line. Repaired alignment scope and rezeroed monitor.
(4) Unit #5 off-line.
(5) Unit #5 off-line.

- All lamp voltage checks performed during the periodic QA checks produced results within the acceptable range except for the 8/4/83 check on Unit No. 5, when the "LAMP" fault was activated. (This problem was resolved during corrective action following the periodic QA check.)

- For both the Units No. 4 and 5 opacity CEMS's, the optical alignment was reported to be acceptable for each of the periodic QA checks. However, repairs to the Unit No. 5 alignment scope were required on one occasion.

- Significant particulate accumulation on the optical surfaces of both monitors sometimes occurs, as indicated by the reduction in apparent effluent opacity when the transceiver and reflector windows were cleaned during the QA checks. (Two methods were used to quantify the apparent dust accumulation. The first method involves comparison of instantaneous opacity readings obtained before and after cleaning each of the optical surfaces. The total dust accumulation is simply the sum of the apparent dust accumulation on the transceiver and reflector windows. The second method determines the total dust accumulation for the monitor by comparing the minimum 6-minute average opacity values during the 1-hour period preceding and following the periodic QA check.)

  The two methods of quantifying dust accumulation on the optical surfaces provided consistent results in most cases. The maximum difference between the results provided by the two methods was 3% opacity for the Unit No. 4 monitor and 5% opacity for the Unit No. 5 monitor.

  The apparent reduction in opacity corresponding to window cleaning exceeded 4% opacity in four of eight checks for the Unit No. 4 CEMS and in three of eight checks for the Unit No. 5 CEMS.

3.3.3 Corrective Action

Because a limited number of people are involved in the operation and maintenance of the opacity CEMS's at the James River Station, the need for documentation of corrective action is diminished. Thus, documentation of most minor corrective actions is usually included as notes in the daily logs or periodic QA checks. Such activities include: (1) unscheduled cleaning of transmissometer windows, (2) resetting of the timer or data logger, and (3) resolving chart recorder problems. At the James River Station, most of these problems are resolved so expeditiously that they are scarcely mentioned in the QA records at all.

The only corrective action log that was completed during the 1-year study corresponded to the lamp reference voltage problem identified during the 8/4/83 periodic QA check of the Unit No. 5 opacity CEMS. The corrective action was necessary to adjust the observed lamp voltage (4.36 volts) to be within the acceptable range specified by the manufacturer (6.5 ± 1.0 volts). As stated in the corrective action log, the entire CEMS set-up procedure was performed after the lamp reference voltage was adjusted. The corrective action log shows that the repair/adjustment procedures were initiated at 0800 on 8/5/83, were completed at 1100 on 8/8/83, and required 36 manhours to complete. This one instance appears to be the only major problem that was encountered for either the Unit No. 4 or No. 5 opacity CEMS during the 1-year project.

3.4 SOURCE SELF AUDIT

Personnel at the James River Station conducted performance audits of the Units No. 4 and 5 opacity CEMS's on May 17, 1984 using audit devices supplied by the project team. Source personnel had previously observed and/or participated in the initial audit, had access to the detailed report for the initial audit, and were furnished a copy of "Performance Audit Procedures for Opacity Monitors" (EPA-340/1-83-010). Using this information, the James River Station personnel conducted the performance audit generally in accordance with the prescribed procedures and completed the necessary data sheets (see Appendix A). The results that were calculated from the data provided by the source self audit are summarized in Tables 3-5 and 3-6 for the Units No. 4 and 5 CEMS's, respectively.

The results of the source self audit show that the Unit No. 4 opacity CEMS met all of the audit criteria except for the optical surface dust accumulation check. The apparent dust accumulation on the transceiver window slightly exceeded the recommended 2% opacity limit, and the total dust accumulation level exceeded the recommended 4% opacity limit by 1% opacity.

For Unit No. 5, the results of the source self audit show that the CEMS met all of the audit criteria.

It should be noted that for the audits of both the Unit No. 4 and No. 5 CEMS's, only one measurement for each filter was obtained during the calibration error test, instead of the five measurements normally obtained. Therefore, it is not possible to determine the confidence interval or the calibration error results (i.e., sum of the mean difference and confidence interval) for either monitor. If the five measurement repetitions had been performed, the CEMS's may not have met the calibration error limit at all three test levels, since the contributions of the confidence intervals could have resulted in excessive calibration error results. The single measurements of each filter indicate an increasing negative bias with increasing opacity for the Unit No. 4 CEMS and somewhat random measurement errors for the Unit No. 5 CEMS.

3.5 FINAL PERFORMANCE AUDIT

A final performance audit of the James River Station Units No. 4 and 5 opacity CEMS's was conducted on June 6, 1984. This audit marked the end of the 1-year field study at the James River Station. Detailed discussions of the findings and results of the final audit are included in the June 1984 audit report for this station.

The results of the final performance audits of the Units No. 4 and 5 opacity CEMS's are summarized in Tables 3-7 and 3-8, respectively. The following conclusions were derived from the results of the final performance audits of the James River opacity monitoring systems:

(1) The Unit No. 5 opacity monitoring system was found to exhibit acceptable performance for all criteria evaluated during the audit except for dust accumulation on optical surfaces.

TABLE 3-5. SUMMARY OF PERFORMANCE AUDIT RESULTS
CITY UTILITIES, JAMES RIVER STATION, UNIT NO. 4
DYNATRON MODEL 1100 OPACITY MONITORING SYSTEM
- SOURCE SELF AUDIT -

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Lamp	Off	Off
Window	Off	Off
Air Flow	Off	Off
Stack Exit Correlation Error	Not Determined	± 2%
Panel Meter Correction Factor	1.00	0.98 to 1.02
Internal Low Range Error	-1.0% Opacity	± 2% Opacity
Internal Span Error	1.0% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	3% Opacity	≤ 2% Opacity
Reflector Window	2% Opacity	≤ 2% Opacity
Total	5% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS*

	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (16.0% Opacity)	1.0%	ND	ND	≤ 3%
Mid Range (41.5% Opacity)	-2.5%	ND	ND	≤ 3%
High Range (55.8% Opacity)	-2.8%	ND	ND	≤ 3%

---

*Only one measurement of each filter was reported; therefore, the confidence interval and calibration error results cannot be determined. The opacity level of the low, mid, and high range checks is the value that results from the superposition of the filter value (corrected to the stack exit pathlength) and the effluent opacity indicated by the monitor.

TABLE 3-6. SUMMARY OF PERFORMANCE AUDIT RESULTS
CITY UTILITIES, JAMES RIVER STATION, UNIT NO. 5
DYNATRON MODEL 1100 OPACITY MONITORING SYSTEM
- SOURCE SELF AUDIT -

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Lamp	Off	Off
Window	Off	Off
Air Flow	Off	Off
Stack Exit Correlation Error	Not Determined	± 2%
Panel Meter Correction Factor	1.00	0.98 to 1.02
Internal Low Range Error	0.0% Opacity	± 2% Opacity
Internal Span Error	-1.0% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	Negligible Opacity	≤ 2% Opacity
Reflector Window	Negligible Opacity	≤ 2% Opacity
Total	Negligible Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS*

	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (10.6% Opacity)	2.6%	ND	ND	≤ 3%
Mid Range (24.9% Opacity)	-0.8%	ND	ND	≤ 3%
High Range (34.4% Opacity)	-0.2%	ND	ND	≤ 3%

*Only one measurement of each filter was reported; therefore, the confidence interval and calibration error results cannot be determined. The opacity level of the low, mid, and high range checks is the value that results from the superposition of the filter value (corrected to the stack exit pathlength) and the effluent opacity indicated by the monitor.

TABLE 3-7. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS
CITY UTILITIES, JAMES RIVER STATION, UNIT NO. 4
DYNATRON MODEL 1100 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Lamp	Off	Off
Window	Off	Off
Air Flow	Off	Off
Stack Exit Correlation Error	Exceeds Limits (see text)	± 2%
Panel Meter Correction Factor	0.984	0.98 to 1.02
Internal Low Range Error (chart)	0.5% Opacity	± 2% Opacity
Internal Low Range Error (data logger)	Not Determined	± 2% Opacity
Internal Span Error (chart)	0.5% Opacity	± 2% Opacity
Internal Span Error (data logger)	1.0% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Sightly off-center but OK	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	15% Opacity	≤ 2% Opacity
Reflector Window	2% Opacity	≤ 2% Opacity
Total	17% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (15.5% Opacity)	-1.3%	0.5%	1.8%	≤ 3%
Mid Range (40.6% Opacity)	-3.0%	0.2%	3.2%	≤ 3%
High Range (54.9% Opacity)	-4.3%	0.1%	4.4%	≤ 3%

TABLE 3-6. SUMMARY OF PERFORMANCE AUDIT RESULTS
CITY UTILITIES, JAMES RIVER STATION, UNIT NO. 5
DYNATRON MODEL 1100 OPACITY MONITORING SYSTEM
- SOURCE SELF AUDIT -

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Lamp	Off	Off
Window	Off	Off
Air Flow	Off	Off
Stack Exit Correlation Error	Not Determined	± 2%
Panel Meter Correction Factor	1.00	0.98 to 1.02
Internal Low Range Error	0.0% Opacity	± 2% Opacity
Internal Span Error	-1.0% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	Negligible Opacity	≤ 2% Opacity
Reflector Window	Negligible Opacity	≤ 2% Opacity
Total	Negligible Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS[*]

	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (10.6% Opacity)	2.6%	ND	ND	≤ 3%
Mid Range (24.9% Opacity)	-0.8%	ND	ND	≤ 3%
High Range (34.4% Opacity)	-0.2%	ND	ND	≤ 3%

---

[*] Only one measurement of each filter was reported; therefore, the confidence interval and calibration error results cannot be determined. The opacity level of the low, mid, and high range checks is the value that results from the superposition of the filter value (corrected to the stack exit pathlength) and the effluent opacity indicated by the monitor.

TABLE 3-7. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS
CITY UTILITIES, JAMES RIVER STATION, UNIT NO. 4
DYNATRON MODEL 1100 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Lamp	Off	Off
Window	Off	Off
Air Flow	Off	Off
Stack Exit Correlation Error	Exceeds Limits (see text)	± 2%
Panel Meter Correction Factor	0.984	0.98 to 1.02
Internal Low Range Error (chart)	0.5% Opacity	± 2% Opacity
Internal Low Range Error (data logger)	Not Determined	± 2% Opacity
Internal Span Error (chart)	0.5% Opacity	± 2% Opacity
Internal Span Error (data logger)	1.0% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Sightly off-center but OK	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	15% Opacity	≤ 2% Opacity
Reflector Window	2% Opacity	≤ 2% Opacity
Total	17% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (15.5% Opacity)	-1.3%	0.5%	1.8%	≤ 3%
Mid Range (40.6% Opacity)	-3.0%	0.2%	3.2%	≤ 3%
High Range (54.9% Opacity)	-4.3%	0.1%	4.4%	≤ 3%

TABLE 3-8. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS
CITY UTILITIES, JAMES RIVER STATION, UNIT NO. 5
DYNATRON MODEL 1100 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Lamp	Off	Off
Window	Off	Off
Air Flow	Off	Off
Stack Exit Correlation Error	0% (Assumed)	± 2%
Panel Meter Correction Factor	1.01	0.98 to 1.02
Internal Low Range Error (chart)	-0.5% Opacity	± 2% Opacity
Internal Low Range Error (data logger)	0.0% Opacity	± 2% Opacity
Internal Span Error (chart)	-1.0% Opacity	± 2% Opacity
Internal Span Error (data logger)	0.0% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	4.0% Opacity	≤ 2% Opacity
Reflector Window	3.0% Opacity	≤ 2% Opacity
Total	7.0% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (9.6% Opacity)	0.4%	0.3%	0.7%	≤ 3%
Mid Range (24.2% Opacity)	-0.6%	1.0%	1.6%	≤ 3%
High Range (33.9% Opacity)	-1.7%	0.6%	2.3%	≤ 3%

(2) The Unit No. 4 opacity monitoring system was found to exhibit acceptable performance for all criteria evaluated during the audit except for (a) stack exit correlation error, (b) dust accumulation on optical surfaces, and (c) mid and high range calibration error.

(3) Although the stack exit correlation error could not be determined directly, the audit results indicate a high probability that the internal pathlength correction factor for the Unit No. 4 monitor was incorrect at the time the audit was performed.

(4) The condensed moisture observed on the Unit No. 4 transceiver window during the audit substantiates statements by plant personnel that this problem occurs during unit outages.

(5) The dust and/or moisture deposited on the optical windows of the Unit No. 4 and No. 5 opacity monitors will bias all opacity measurements high. However, the amount of dust accumulation on the optical surfaces observed during the audit may not be representative of normal conditions, because (a) both Units No. 4 and 5 had been off-line for several days preceding the audit and were off-line during the audit, and (b) the problem identified in (4) above is reported to occur only during source outages.

(6) Residual effluent opacity is present at both the Units No. 4 and 5 monitoring locations when the units are not operating.

(7) The failure of the Unit No. 4 monitor to achieve acceptable performance for the calibration error test is believed to be due primarily to a shift or change in the monitor's internal pathlength correction factor.

3.6 CEMS DOWNTIME

Figure 3-6 illustrates the total CEMS downtime for the James River Station, Units No. 4 and 5, as reported in excess emission reports from the first quarter of 1982 through the second quarter of 1984. The data for 1982 were obtained from summaries prepared by the Missouri DNR; the data for 1983 and 1984 were obtained from a detailed review of quarterly reports submitted by City Utilities to the Missouri DNR. (See " An Analysis of Opacity CEMS Downtime in Excess Emission Reports: Opacity CEM Pilot Project" (May 1986) for additional discussions and comparative results for other sources.)

As can be seen from Figure 3-6, CEMS downtime for both Units No. 4 and 5 decreased from a value of approximately 4% (85 hours), for the first quarter that data were reported, to a minimum level, which was consistently below 0.6% (14 hours), for all subsequent reporting periods. Thus, both of the opacity CEMS's at the James River Station achieved very high levels of monitor availability (i.e., greater than 99% during the field study). Almost all of the CEM downtime that has occurred at the James River Station is attributable to (1) cleaning of transmissometer windows, (2) changing chart recorder paper, (3) resetting of the data logger/timer, and (4) preventive maintenance/monthly monitor checks.

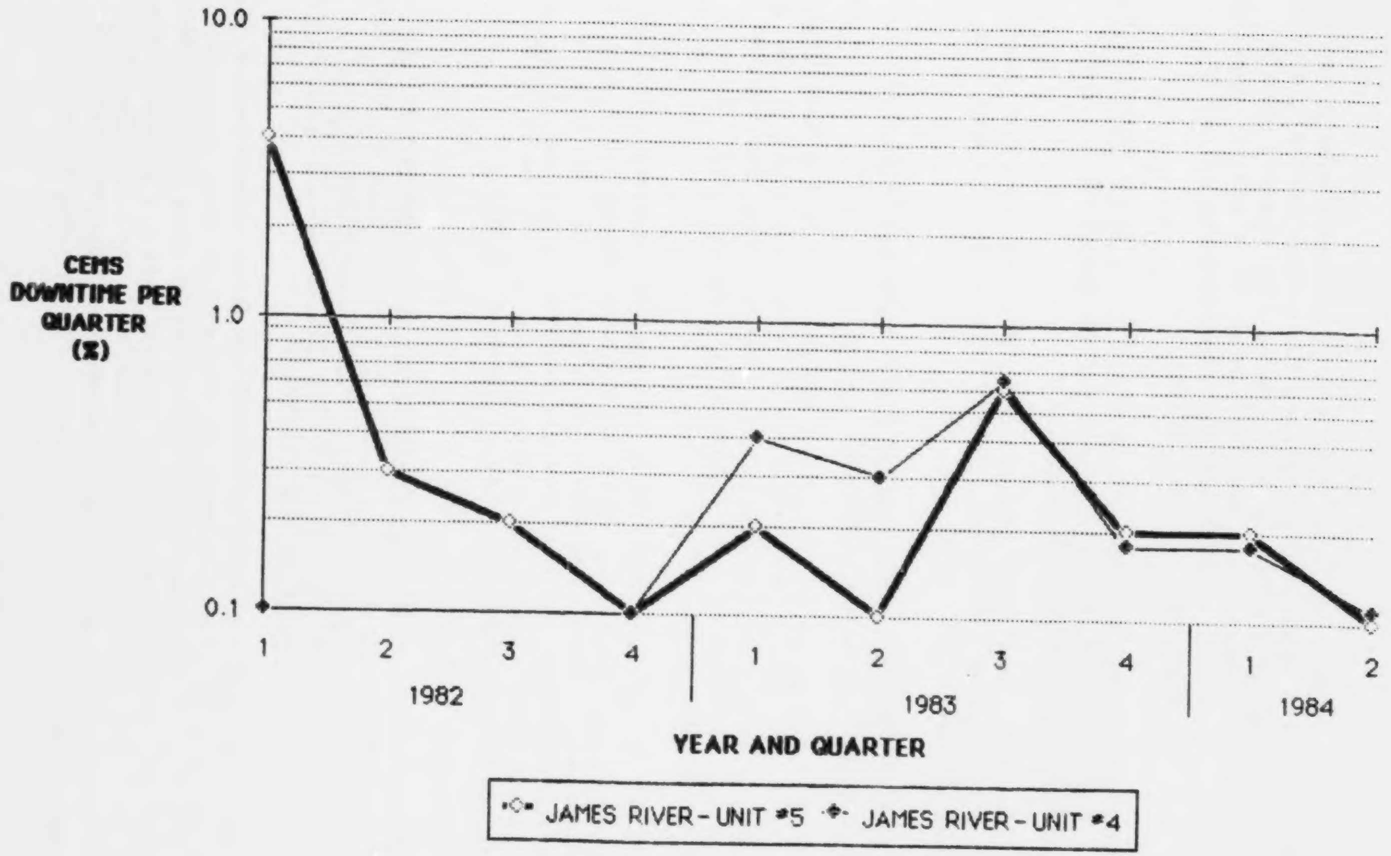


FIGURE 3-6. CEMS DOWNTIME - JAMES RIVER UNITS NO. 4 AND 5

During the 1-year field study, there was some reduction in the reported frequency of window cleaning that slightly increased CEMS availability. However, offsetting these small gains, a small increase in CEM downtime was associated with the time required to perform the periodic QA checks (which include window cleaning). Overall, there is no indication that the time required to perform QA procedures detracted from the opacity CEMS's availability.

3.7 CONCLUSIONS

The evaluation of the results obtained from the performance audits and from the implementation of quality assurance procedures shows that reliable opacity monitoring data are provided by the two Dynatron Model 1100 opacity CEMS's installed at City Utilities' James River Station, Units No. 4 and 5. Specific conclusions regarding monitor performance and the effectiveness of the QA procedures used during the study are provided below.

1. The Dynatron opacity CEMS's installed on Units No. 4 and 5 both achieved exceptionally high levels of availability during the study (i.e., greater than 99% for each calendar quarter).

   (These availability results are expressed relative to the total number of hours in each quarter, since the opacity CEMS's are operated even during boiler outages.)

2. The Dynatron opacity CEMS's are capable of providing precise and accurate effluent opacity measurements.

   o For both the Unit No. 4 and 5 opacity CEMS's, all of the daily "zero" (i.e., low range) checks were within ± 2% opacity and all of the span checks were within ± 1% opacity of the correct values during the 1-year study. No zero or span adjustments were made for either monitor during the study.

   o The accuracy of the Unit No. 5 opacity CEMS was consistently within ± 3% opacity as indicated by calibration error checks for three performance audits conducted during the study. Although a minor calibration shift was observed for the Unit No. 4 opacity CEMS, monitor accuracy was found to be within ± 5% opacity as indicated by calibration error checks for three performance audits.

3. A high bias in opacity measurements sometimes occurs because of the accumulation of excessive amounts of dust and/or moisture on the exposed optical surfaces of the opacity CEMS's. However, actions taken by station personnel prevent this problem from significantly affecting the identification of periods of excess emissions.

   (The results of several of the periodic QA checks and performance audits indicated exceedances of the 4% opacity dust accumulation limit for both monitors. This problem often occurs during boiler outages. However, since the optical surfaces are usually cleaned when the boiler operators observe higher than expected opacity values, this problem does not result in the reporting of periods of apparent excess emissions that are actually due to particulate accumulation on the optical surfaces.)

4. The WINDOW fault lamp at the monitor control unit does not provide an accurate indication of when excessive dust accumulation on the opacity surfaces of the transmissometer occurs for either the Unit No. 4 or No. 5 opacity CEMS.

(Although several occasions were documented when the transceiver dust accumulation exceeded 4% opacity, the WINDOW fault indicators were never activated for either monitor. Thus, for both monitors either (1) the WINDOW fault sensitivity level is incorrectly adjusted or (2) the WINDOW fault system simply does not work properly. The WINDOW fault system only detects dust on the transceiver optics. Since different levels of dust accumulation are sometimes observed for the transceiver and reflector windows at the James River Station, the window fault system cannot provide a reliable indication of the total dust accumulation. Station personnel are aware of the above limitations; therefore, they clean the optical surfaces when higher than expected opacity values are observed.)

5. Completion of a daily QA check log is not necessary in order to maintain opacity CEMS's within control limits at the James River Station.

(The daily QA checks typically required 2 minutes per day per monitor to perform during the 1-year study. Performance of the daily "zero" and span checks is required by the applicable regulations; checks of the other parameters included in the daily QA check procedures are recommended. However, the completion of daily QA check logs should be eliminated to reduce the record keeping burden, since (a) the same person, who is thoroughly familiar with the operation of the opacity CEMS, performs almost all of the daily checks, and (b) the parameters included in the daily QA checks proved to be very stable over the study. Maintenance of a control chart similar to the daily QA check summaries in Appendix A may be useful in tracking monitor performance over time.)

6. Periodic QA checks and performance audits are effective for the identification of monitor operational problems that may otherwise be overlooked.

(Both the periodic QA checks and the performance audit results documented occurrences of excessive dust accumulation on the optical surfaces of the opacity CEMS's. The two methods for quantifying dust accumulation that were included in the periodic QA checks provided consistent results in most cases. The periodic QA checks also revealed the need for (1) repairs to the Unit No. 5 monitor alignment scope and (2) corrective action to resolve a problem with the Unit No. 5 monitor lamp reference voltage. In addition, the performance audit results identified a slight shift in the Unit No. 4 monitor calibration.)

7. James River Station personnel have demonstrated the necessary expertise and capability to operate and maintain the installed opacity CEMS's properly.

(Prior to the 1-year study, station personnel had developed successful solutions for several unique monitor problems (including: design and fabrication of prototype transition pieces to eliminate corrosion problems, improvements in the monitor optical alignment sight, and elimination of water runoff problems during severe rainstorms). During the study, station personnel completed the QA checks and necessary repairs and adjustments properly and expeditiously. They also successfully conducted performance audits of the opacity CEMS's. As evidenced by interviews conducted before and after the study period and by the results obtained at the James River Station, source personnel both understand how the CEMS works and take pride in achieving successful monitor performance.)

4.0 UNION ELECTRIC COMPANY, PORTAGE DES SIOUX, UNITS NO. 1 AND 2

This section provides relevant background information and a summary and discussion of results obtained from both (1) the implementation of quality assurance procedures and (2) the performance audits of the installed opacity CEMS's at Union Electric Company's Portage Des Sioux Station, Units No. 1 and 2. An overview of the field study conducted for these two units is provided in Figures 4-1 and 4-2.

4.1 SOURCE AND MONITOR DESCRIPTIONS

4.1.1 Source Description

The Union Electric Company, Portage Des Sioux Station is composed of two coal-fired electric utility steam generating units, each rated at approximately 489 MW. Units No. 1 and 2 are completely independent; each is equipped with twin electrostatic precipitators (ESP's) for control of particulate emissions and a separate exhaust stack. For each unit, the boiler effluent is divided evenly, routed through twin ESP's and twin I.D. fans, and subsequently recombined in the exhaust stack. Both Units No. 1 and 2 are subject to a Missouri opacity limit of 20% opacity.

4.1.2 Monitor Description

The Lear Siegler, Inc. (LSI) opacity monitoring systems utilized for Units No. 1 and 2 at the Portage Des Sioux Station are identical. Each monitoring system consists of two RM41 transmissometers (one transmissometer installed in each of the two breeching ducts serving each unit), a Model 21-622 Emissions Monitor Combiner (which also serves as the control unit for both transmissometers), and a dual pen strip chart recorder. In addition, a dedicated digital computer/data logger (LSI DP-30) is used to record and report data obtained from both the Units No. 1 and 2 monitoring systems. A schematic diagram of the Sioux Station opacity CEMS's is shown in Figure 4-3. The monitor combiner units, the strip chart recorders, and the computer-output printer are located in the boiler control room. Normally, both instantaneous and 6-minute average effluent opacity measurements (corrected to stack exit conditions) are displayed on the strip chart recorders for each generating unit. On command, the computer/data logger prints instantaneous effluent opacity values at 1-minute intervals for either the Unit No. 1 or No. 2 monitoring systems. An hourly emissions summaries (containing 6-minute average opacity values), a daily summary, and a weekly report are generated by the computer/data logger system.

The Sioux opacity CEMS's are inherently more complex than most opacity monitoring systems, since the outputs of two duct-mounted transmissometers are combined and corrected for pathlength changes to provide a single result equivalent to the opacity of the effluent at the stack exit. At the Sioux Station, the process of determining the equivalent stack exit opacity is performed separately by both the combiner and the digital computer. The same input signals from the two transmissometers are provided to both the combiner and the computer. (The two data processing devices are arranged in series with respect to the "reference" and "measurement" current loops for each of the monitors.) The combiner determines the equivalent stack-exit opacity using

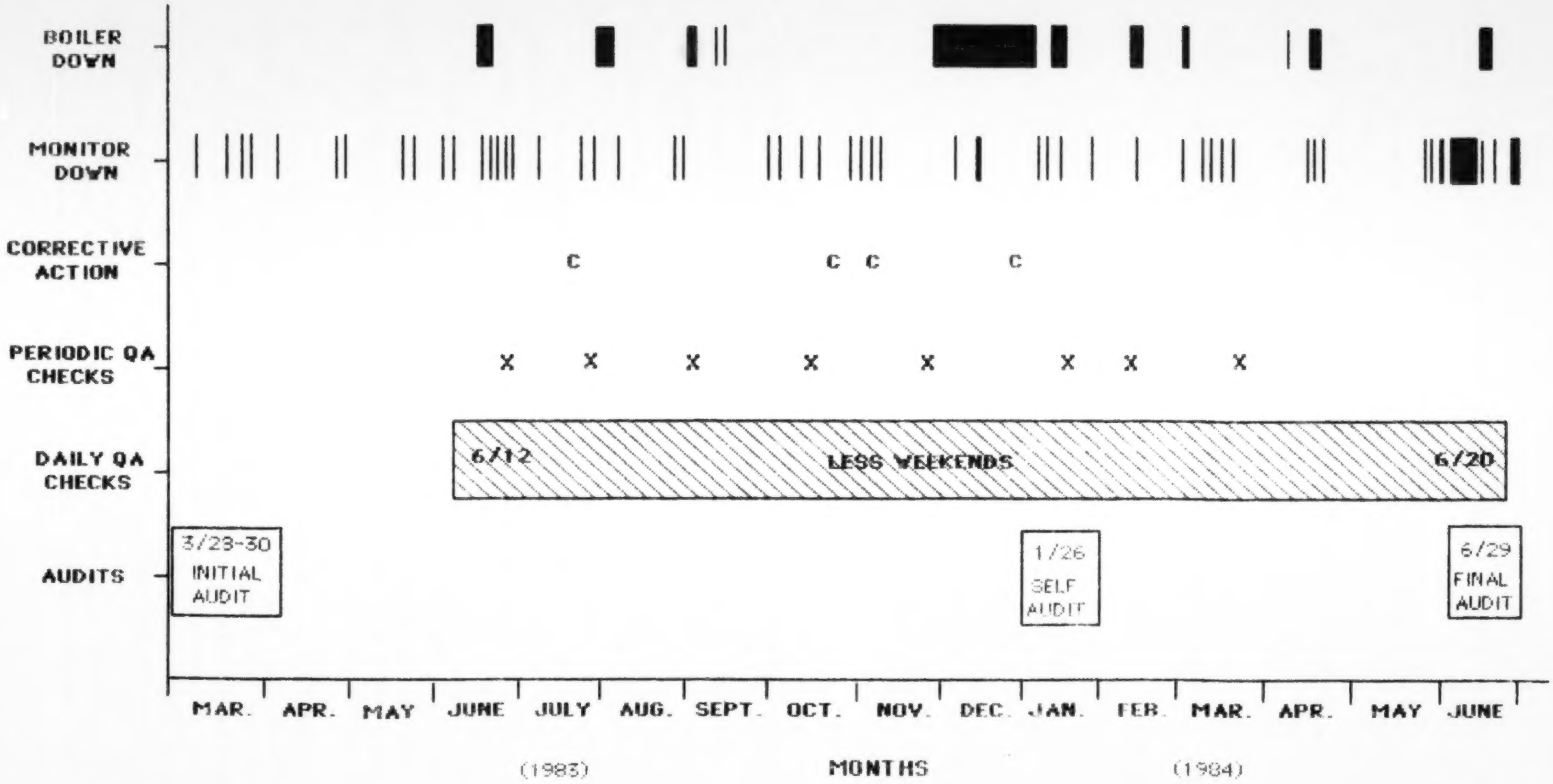


FIGURE 4-1. UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION, UNIT NO. 1: OPACITY CEMS PROJECT STUDY

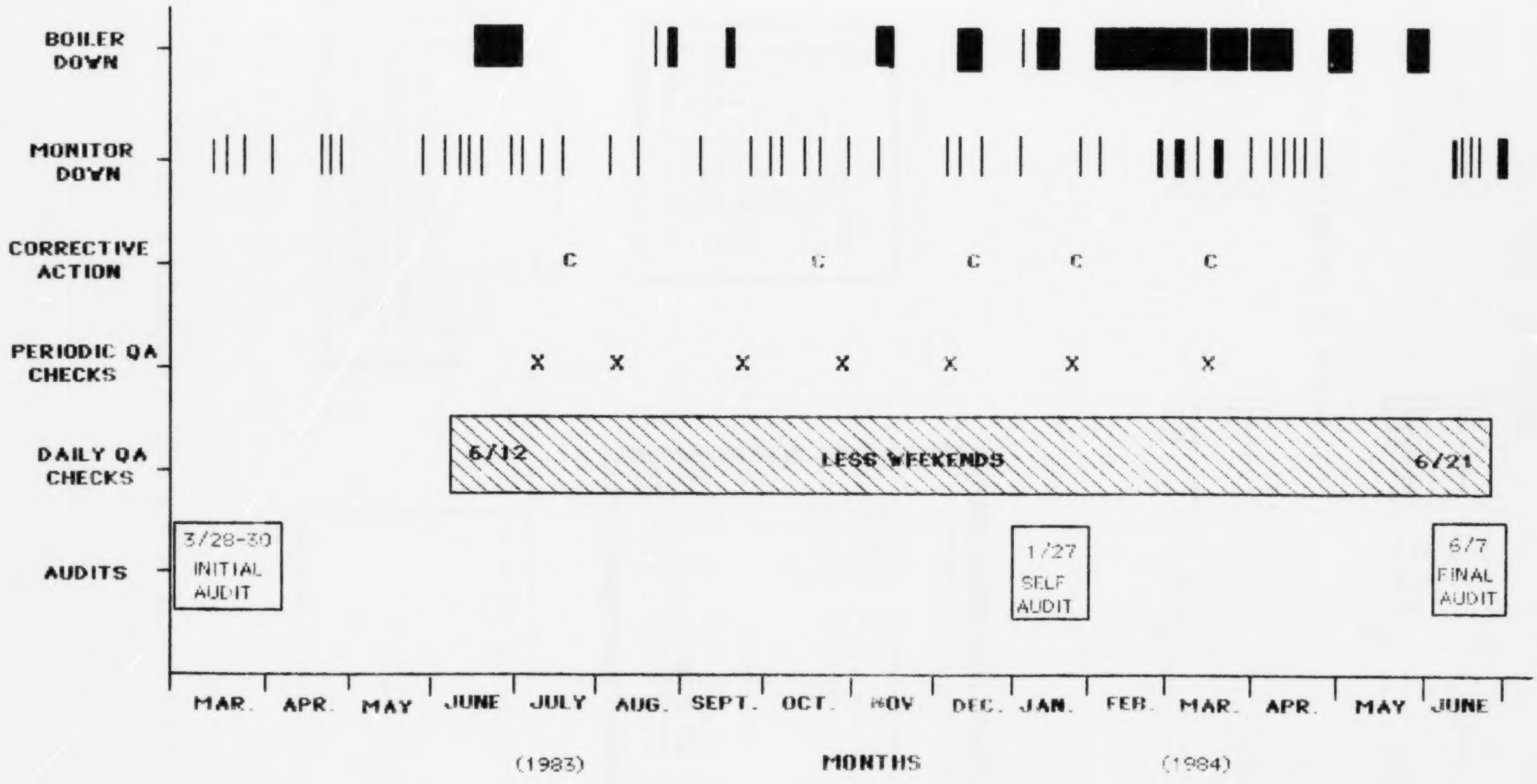


FIGURE 4-2 UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION, UNIT NO. 2: OPACITY CEMS PROJECT STUDY

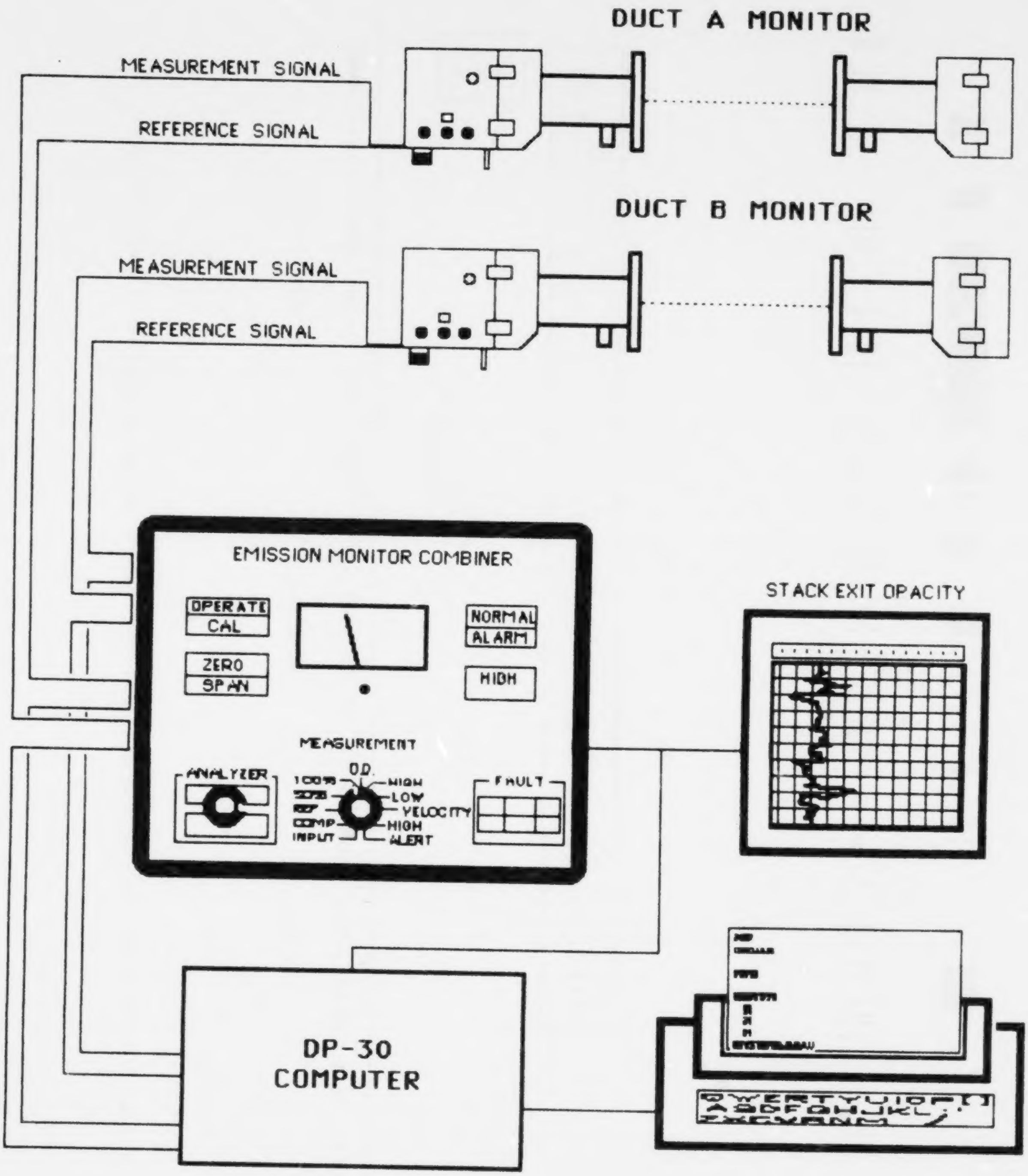

DUCT A MONITOR
MEASUREMENT SIGNAL
REFERENCE SIGNAL
DUCT B MONITOR
MEASUREMENT SIGNAL
REFERENCE SIGNAL
EMISSION MONITOR COMBINER
OPERATE
CAL
ZERO
SPAN
NORMAL
ALARM
HIGH
MEASUREMENT
ANALYZER
O.D.
100%
REF
COMP
INPUT
HIGH
LOW
VELOCITY
HIGH
ALERT
FAULT
STACK EXIT OPACITY
DP-30
COMPUTER
QWERTYUIOP[]
ASDFGHJKL
ZXCVBNM

Figure 4-3. Schematic diagram of opacity CEMS

analog electronic circuitry, and provides an analog output signal that serves as the input signal for the strip chart. Independently, the computer converts the analog "reference" and "measurement" current signals to digital values, and then calculates the equivalent stack-exit opacity. In addition, the output signal from the combiner is routed to the computer, converted to a digital signal, and then compared to the stack-exit opacity calculated by the computer. The comparison of the digital and analog stack-exit opacity values provides a check on the degree of agreement between the two data processing methods, and is used to flag operating problems in the computer printout.

In theory, the determination of the equivalent stack-exit opacity where multiple duct-mounted transmissometers are used requires determination of both effluent opacity and volumetric flow rate at each monitoring location. At the Sioux Station, the effluent volumetric flow rates are assumed to be identical at the two monitoring locations on each generating unit.

4.2 INITIAL AUDIT

Initial audits of the opacity CEMS's installed at the Sioux Station Units No. 1 and 2 were performed on March 28-30, 1983. The audits included (1) a visual evaluation of the monitor installation location, (2) a systems audit (i.e., a qualitative evaluation of monitor operation, maintenance, and record keeping practices), and (3) a performance audit of each opacity CEMS (i.e., a quantitative evaluation of monitor accuracy and precision). In addition, a dual audit experiment was performed for the Unit No. 2 opacity CEMS. Detailed discussions of the findings and results of the initial audits are included in the March 1983 audit report for this station.

The results of the initial performance audits of the Unit No. 1 A- and B-side monitors are summarized in Tables 4-1 and 4-2, and the results for the Unit No. 2 A- and B- side monitors are summarized in Tables 4-3 and 4-4, respectively. The results of the dual audit experiment are shown in Table 4-5. The following conclusions were derived from the initial audits of the Sioux Station opacity monitoring systems.

Monitor Installation Location

1. The Sioux Station opacity monitoring systems are installed in the best available locations for monitoring the performance of the individual ESP's. It is believed that the monitoring locations provide opacity measurements that are representative of the entire effluent stream at each measurement location.

2. The Sioux Station opacity monitoring systems are not subject to any known adverse environmental conditions.

3. The excellent access to all of the installed transmissometers on Units No. 1 and 2 facilitates performance of necessary monitor maintenance activities.

TABLE 4-1. SUMMARY OF INITIAL PERFORMANCE AUDIT RESULTS
UNIT NO. 1, MONITOR A
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	Not Determined	± 2%
Control Panel Status:		
Opacity Scale Factor	1.03	0.98 to 1.02
Optical Density Scale Factor	1.05	0.98 to 1.02
Reference Signal Analysis	-4.5%	± 10%
Internal Zero Error	0.0% Opacity	± 2% Opacity
Internal Span Error	-0.1% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Cleaning	.003 OD	±.018 OD
After Cleaning	.002 OD	±.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	1.5% Opacity	≤ 2% Opacity
Reflector Window	0.5% Opacity	≤ 2% Opacity
Total	2.0% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (15.2% Opacity)				
Panel Meter	-0.55%	0.14%	0.7%	≤ 3%
Strip Chart	-0.21%	0.68%	0.9%	≤ 3%
Computer	-0.63%	0.11%	0.7%	≤ 3%
Mid Range (34.9% Opacity)				
Panel Meter	-1.96%	0.81%	2.8%	≤ 3%
Strip Chart	-0.06%	1.43%	1.5%	≤ 3%
Computer	-1.21%	0.09%	1.3%	≤ 3%
High Range (62.4% Opacity)				
Panel Meter	-2.25%	1.11%	3.4%*	≤ 3%
Strip Chart	-0.15%	2.04%	2.2%	≤ 3%
Computer	-1.35%	0.00%	1.4%	≤ 3%

*See text

TABLE 4-2. SUMMARY OF INITIAL PERFORMANCE AUDIT RESULTS
UNIT NO. 1, MONITOR B
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	Not Determined	± 2%
Control Panel Status:		
Opacity Scale Factor	1.02	0.98 to 1.02
Optical Density Scale Factor	1.07	0.98 to 1.02
Reference Signal Analysis	2.5%	± 10%
Internal Zero Error	3.5% Opacity*	± 2% Opacity
Internal Span Error	0.4% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Cleaning	.004 OD	±.018 OD
After Cleaning	.002 OD	±.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	No Data	≤ 2% Opacity
Reflector Window	No Data	≤ 2% Opacity
Total	No Data	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (15.2% Opacity)				
Strip Chart	4.01%	0.34%	4.4%	≤ 3%
Computer	0.01%	0.18%	0.2%	≤ 3%
Mid Range (34.9% Opacity)				
Strip Chart	2.14%	0.00%	2.1%	≤ 3%
Computer	-0.95%	0.82%	1.8%	≤ 3%
High Range (62.4% Opacity)				
Strip Chart	0.55%	0.28%	0.8%	≤ 3%
Computer	-1.30%	0.42%	1.7%	≤ 3%

*Result obtained from panel meter; strip chart value not recorded.

TABLE 4-3. SUMMARY OF INITIAL PERFORMANCE AUDIT RESULTS
UNIT NO. 2, MONITOR A
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	Not Determined	± 2%
Control Panel Status:		
Opacity Scale Factor	1.01	0.98 to 1.02
Optical Density Scale Factor	1.02	0.98 to 1.02
Reference Signal Analysis	-1.5%	± 10%
Internal Zero Error	0.0% Opacity	± 2% Opacity
Internal Span Error	0.2% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Cleaning	-.001 OD	±.018 OD
After Cleaning	.002 OD	±.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	0.0% Opacity	≤ 2% Opacity
Reflector Window	0.0% Opacity	≤ 2% Opacity
Total	0.0% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (15.3% Opacity)				
Panel Meter	-0.08%	0.41%	0.5%	≤ 3%
Strip Chart	0.04%	0.31%	0.4%	≤ 3%
Computer	-0.48%	0.27%	0.8%	≤ 3%
Mid Range (35.1% Opacity)				
Panel Meter	-1.11%	0.15%	1.3%	≤ 3%
Strip Chart	-0.65%	0.07%	0.7%	≤ 3%
Computer	-0.87%	0.38%	1.3%	≤ 3%
High Range (62.7% Opacity)				
Panel Meter	-2.64%	0.77%	3.4%	≤ 3%
Strip Chart	-1.34%	0.29%	1.6%	≤ 3%
Computer	-1.16%	0.28%	1.4%	≤ 3%

TABLE 4-4. SUMMARY OF INITIAL PERFORMANCE AUDIT RESULTS
UNIT NO. 2, MONITOR B
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM

	Audit Result	Acceptable Result
MONITOR COMPONENT ANALYSIS		
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	Not Determined	± 2%
Control Panel Status:		
Opacity Scale Factor	1.02	0.98 to 1.02
Optical Density Scale Factor	1.03	0.98 to 1.02
Reference Signal Analysis	-0.5%	± 10%
Internal Zero Error	0.0% Opacity	± 2% Opacity
Internal Span Error	0.5% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Cleaning	.008 OD	±.018 OD
After Cleaning	---	±.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	1.0% Opacity	≤ 2% Opacity
Reflector Window	0.0% Opacity	≤ 2% Opacity
Total	1.0% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (15.3% Opacity)				
Panel Meter	-0.42%	0.65%	1.1%	≤ 3%
Strip Chart	0.30%	0.20%	0.5%	≤ 3%
Computer	-0.96%	0.23%	1.2%	≤ 3%
Mid Range (35.1% Opacity)				
Panel Meter	-1.35%	0.19%	1.5%	≤ 3%
Strip Chart	-0.83%	0.27%	1.1%	≤ 3%
Computer	-1.59%	0.14%	1.7%	≤ 3%
High Range (62.7% Opacity)				
Panel Meter	-2.68%	0.00%	2.7%	≤ 3%
Strip Chart	-1.00%	0.20%	1.2%	≤ 3%
Computer	-1.90%	0.06%	2.0%	≤ 3%

TABLE 4-5. DUAL AUDIT EXPERIMENT DATA AND RESULTS

TEST NO.	EQUIVALENT FILTER VALUE					MEASUREMENTS									
#	A-SIDE*		B-SIDE*		EXIT**	A-SIDE		B-SIDE		EXIT OPACITY (%)					
	OPACITY %	OD	OPACITY %	OD	OPACITY %	OD	Δ	OD	Δ	METER		RECORDER		COMPUTER	
										%	Δ	%	Δ	%	Δ
1 (LO)	9.5	.043	0	0	9.4	.02	-.023	0	0	6.8	-2.6	7.2	-2.2	7.2	-2.2
2 (MO)	18.5	.089	0	0	18.5	.065	-.024	0	0	16.1	-2.4	16.5	-2.0	16.5	-2.0
3 (HO)	56.0	.356	0	0	55.8	.322	-.034	0	0	51.8	-4.0	53.0	-2.8	53.4	-2.4
4 (HL)	56.0	.356	8.0	.036	59.3	.322	-.034	.02	-.016	55.5	-3.8	56.5	-2.8	57.1	-2.2
5 (HM)	56.0	.356	19.5	.094	64.4	.322	-.034	.08	-.014	.60.5	-3.9	60.9	-3.5	62.1	-2.3
6 (HH)	56.0	.356	39.0	.215	73.0	.322	-.034	.195	-.02	69.5	-3.5	70.5	-2.5	71.8	-1.2
7 (MH)	18.5	.089	39.0	.0215	50.2	.065	-.024	.195	-.02	46.5	-3.7	47.8	-2.4	47.9	-2.3
8 (LH)	9.5	.043	39.0	.215	44.7	.02	-.023	.195	-.02	41.0	-3.7	42.0	-2.7	42.3	-2.4
9 (OH)	0	0	39.0	.215	39.0	0	0	.195	-.02	36.0	-3.0	37.0	-2.0	37.6	-1.4
10 (OM)	0	0	19.5	.094	19.4	0	0	.08	-.014	17.9	-1.5	18.0	-1.4	18.4	-1.0
11 (OL)	0	0	8.0	.036	7.9	0	0	.02	-.016	6.9	-1.0	7.0	-0.9	7.5	-0.4
12 (LL)	9.5	.043	8.0	.036	16.6	.02	-.023	.02	-.016	14.5	-2.1	14.7	-1.9	14.4	-2.2
13 (ML)	18.5	.089	8.0	.036	24.9	.07	-.019	.02	-.016	23.2	-1.7	23.2	-1.7	23.0	-1.9
14 (MM)	18.5	.089	19.5	.094	34.3	.07	-.019	.08	-.014	31.2	-3.1	32.0	-2.3	32.2	-2.1
15 (LM)	9.5	.043	19.5	.094	27.0	.02	.023	.08	-.014	24.7	-2.3	25.0	-2.0	24.60	-2.4
16 (OO)	0	0	0	0	0	0	0	0	0	-0	?	-0	?	0	0
						AVG.	-.0026		-.017		-2.82		-2.21		-1.89

* Values are actual single pass filter values

**Equivalent opacity at stack exit
Δ = Measurement - equivalent filter value

Monitor Operation, Maintenance, and Record Keeping

1. The Sioux Station opacity monitoring systems were reported to have operated relatively reliably. High levels of monitor availability are normally achieved.

2. Solutions for most previously encountered monitor problems have been devised by source personnel. The individual who is responsible for review of monitoring data and identification of operational problems is thoroughly knowledgeable and familiar with the opacity monitoring instrumentation.

3. A detailed routine maintenance program has been developed and is implemented on a monthly basis. The routine maintenance program, in conjunction with an extensive spare parts inventory, contribute significantly to the reliability of monitoring data obtained at the Sioux Station.

Monitor Performance

1. The Sioux Station opacity monitoring systems were found to exhibit acceptable performance for almost all of the monitor component and maintenance analyses criteria evaluated during the initial performance audit. Only very minor problems associated with the accuracy of panel meter readings were observed. (The panel meter is rarely, if ever, used by the monitor operators at the Sioux Station.)

2. Calibration error test results for the Units No. 1 and 2 opacity CEMS's and the dual audit experiment for the Unit No. 2 CEMS all show that the computer provides the most accurate data, the strip chart recorder is slightly less accurate, and the panel meter is the least accurate of the three data display devices.

3. All 33 calibration error test results for the four individual opacity monitors and the various data display devices were $\leq$ 4.4% opacity.

4. Based upon the computer data, all four individual opacity monitors meet the applicable calibration error specification ($\leq$ 3% opacity).

5. Based upon the strip chart responses, only the Unit No. 1 B-side opacity monitor failed to meet the calibration error specification. This monitor failed to meet the calibration error specification only for the low range test.

6. The calibration error tests of the individual Unit No. 2 monitors and the Unit No. 2 dual audit experiment provided functionally equivalent results.

4.3 QUALITY ASSURANCE PROCEDURES

Draft quality assurance procedures were developed for the Sioux Station Unit No. 1 and 2 opacity CEMS's. The QA procedures consisted of daily checks, periodic QA procedures, and criteria and general procedures for use in performing corrective action for the opacity CEMS's. During the initial audits of the opacity CEMS's, additional information was obtained which allowed for revision of the draft QA procedures. Suggestions for improvement and simplification of the QA procedures were provided by Union Electric personnel. Implementation of the QA procedures began on June 12, 1983. Union Electric Company personnel provided additional revisions to the corrective action procedures on February 29, 1984. Based on a review of the QA data obtained during the first 6 months of the field study, additional recommendations for revisions to the QA procedures were developed by the pilot project team. (A copy of the QA procedures developed during the study is included in Appendix B of this report.) The following sections provide a brief description of the QA procedures, a summary of the QA data, and a discussion of the results of implementing the QA program.

4.3.1 Daily QA Checks

The daily check procedures involve only simple checks of monitor operation that can be performed at the monitor control unit. The purpose of these checks is to determine whether the opacity CEMS is apparently operating properly or if corrective action is necessary. For the LSI opacity CEMS's at the Sioux Station, these procedures involved: (1) a check of whether fault lamps were illuminated, (2) a check of the zero compensation values for both the A- and B-side monitors, (3) zero and span checks of the opacity CEMS's for both the strip chart recorder and the computer system responses, and (4) a check of the computer system output for flags and/or error messages. The time required to perform the QA checks, as well as the boiler downtime during the preceding 24-hour period, were also noted on the daily log. An example daily log is shown in Figure 4-4.

Summaries of all of the daily QA check results from June 12, 1983 until June 20, 1984 for both Units No. 1 and 2 are included in Appendix B of this report. These summaries contain all of the information recorded on the daily logs in a condensed format. With very few exceptions, the daily log sheets were completed each day, including those periods during which the boiler was not operating.

Fault Lamp Indicators

Each of the RM41 combiners are equipped with five fault lamps which, when illuminated, warn of monitor malfunctions. These fault lamps and brief explanations of their functions are:

(1) REF	- Indicates when the reference current level is outside of the acceptable range.
(2) WINDOW	- Indicates when the zero compensation, and thus, the dust accumulation on the transceiver optics exceeds acceptable range.

Opacity Monitoring System

DAILY LOG

UNION ELECTRIC SIOUX STATION UNIT: 1

I. GENERAL INFORMATION

Name: A. ELAM Date: 6/12/83 Time Start: 05:00

TOTAL BOILER O.O.S. TIME (PREVIOUS 24 HOURS): 0

II. COMBINER DATA

FAULT LAMPS ON?	NO	YES
Filter	✓	
Shutter	✓	
Ref	✓	
Windows	✓	
Over Range	✓	

Zero Compensation Level: Monitor A COMP (OD): .005 Monitor B COMP (OD): .012

Chart Recorder, Zero Value: 0 Span Value: 64

III. DP-30 HOURLY REPORT DATA

Zero Calibration: 0.24 Span Calibration: 70.73

	NO	YES
Does zero value exceed acceptable limits of + 2.5% opacity?	✓	
Does span value exceed acceptable limts (67.5% to 72.5% opacity)?	✓	

Reason Code/Flags (Circle those present on hourly report)

00 * D M R A

	NO	YES
Is the "M" or "R" Flag present?	✓	

Error Messages Present on Hourly Report?	NO	YES
1. A/D REFERENCE FAULT	✓	
2. DIGITAL/ANALOG DIFFERENTIAL ALARM	✓	
3. A/D TIME OUT	✓	

IF YES ANSWERS ARE INDICATED FOR ANY OF THE ABOVE QUESTIONS, A JOB REQUISITION SHOULD BE INITIATED

IV. COMMENTS: J.R. No. ________ was initiated

TIME COMPLETED: 05:10

Route: Operating Engineer
File 4-13-26(d)
SP-192

FIGURE 4-4. EXAMPLE OPACITY CEMS DAILY LOG: UNION ELECTRIC CO., PORTAGE DES SIOUX

(3) OVER RANGE - Indicates that the measurement value exceeds the selected optical density range.

(4) SHUTTER - Indicates that the protective shutter has been inserted into the light path to protect the monitor from the effluent.

(5) FILTER - Indicates a problem with the purge air system.

During the 1-year study, the daily log sheets indicate that fault indicators were activated on the following occasions:

Unit No. 1

(1) 6/15-17/83 - SHUTTER fault indicator activated

(2) 6/18-21/83 - SHUTTER and REF (reference) fault indicators activated

(3) 6/23/83 - REF (reference) fault indicator activated

(4) 12/30/83-1/10/84 - SHUTTER fault indicator activated (unit off-line)

Unit No. 2

(1) 9/16/83 - OVER RANGE fault indicator activated

(2) 10/6/83 - WINDOW fault indicator activated

(3) 12/7/83 - WINDOW fault indicator activated

(4) 1/10/84 - SHUTTER and WINDOW fault indicators activated

(5) 2/22/84 - WINDOW fault indicator activated

(6) 3/4-5/84 - All fault indicators activated (bus outage)

(7) 3/17/84 - WINDOW fault indicator activated

(8) 4/30/84 - WINDOW fault indicator activated

(9) 5/16/84 - WINDOW fault indicator activated

On most occasions, a Job Requisition (i.e., corrective action) was initiated the same day or the day after the problem was observed, with the exception of those problems that were resolved simply by performing a manual zero/span check of the CEMS's. In many cases, the monitors were restored to proper operation prior to the time the daily check was performed the following day. All of the problems that occurred were considered relatively minor, and are not indicative of chronic or continuing reliability problems with the opacity monitors.

For Unit No. 1, three of the four problems that occurred took place during the first two weeks of the implementation of the draft QA procedures. The cause of the SHUTTER fault that occurred from 12/30/83 until 1/10/84 was a failure of the instrument air line that is used in place of a purge air blower for this monitor. This problem continued for a number of days; however, the generating unit was off-line during this period for a major outage.

For Unit No. 2, the OVER RANGE problem on 9/16/83 was attributed to a temporary interruption of power to the monitor. Power was again interrupted on 3/4-5/84, resulting in the activation of all of the fault lamps. The six WINDOW faults observed for Unit No. 2 occurred at intervals of 3 to 8 weeks and, in each case, were resolved expeditiously.

Zero Checks

A check of each of the opacity monitoring systems' responses at the zero opacity level is performed at least once per day using the RM41 zero mirror to simulate clear path conditions. The monitors' responses to this check, as indicated by the DP-30 computer printout and by the strip chart, were recorded on the daily log. According to the QA procedures, adjustment of the monitor was to be performed when the monitor response indicated by the DP-30 printout exceeded ± 2.5% opacity during the zero check.

During the 1-year study, the following exceedances of the ± 2.5% opacity zero check control limit occurred for the Unit No. 1 CEMS:

(1) 6/22/83 - Zero check values: strip chart = 4%; DP-30 = 2.64%

(2) 11/5/83 - Zero check values: strip chart = 4%; DP-30 = 1.03%

(3) 6/10/84 - Zero check values: strip chart = 3%; DP-30 = 0.76%

The Unit No. 1 zero check control limit exceedance indicated by the chart recorder on 11/5/83 was not supported by the value indicated by the DP-30 printout. Notations on the daily log sheets for the three following days indicated that errors were made by the same operator in determining the chart recorder zero responses. Therefore, it appears that the apparent zero check exceedance indicated by the strip chart may have been due to a chart reading error.

For the Unit No. 2 opacity CEMS, no exceedances of the ± 2.5% opacity zero drift limit were indicated by either the DP-30 or the chart recorder data during the 1-year study except for (1) the zero values recorded during the bus outage (3/4-5/84) and (2) obvious recording errors.

An extremely small number of exceedances of the zero control limit for the Sioux Station opacity monitoring systems were observed. For both the Unit No. 1 and 2 monitoring systems, the tabulated strip chart data exhibit greater variations than do the DP-30 data; part of this variability may be due to imprecision in reading the chart record. For both Units, the zero check responses indicated by the DP-30 typically varied by approximately 0.1% opacity, and rarely varied more than 0.5% opacity from day to day.

Zero Compensation

The LSI RM41 opacity monitors are equipped with a zero compensation feature that automatically adjusts the measured opacity value to compensate for dust accumulation on the exposed optical surfaces of the transceiver unit. Cleaning of the optical surfaces is recommended when the level of zero compensation exceeds ± 0.018 optical density (i.e., ± 4% opacity); however, this activity is not required as part of the QA procedures.

Zero compensation values were recorded on the daily log sheets for both the A- and B-side transmissometers of the Unit No. 1 and 2 monitoring systems. A review of the zero compensation data indicates the following results:

(1) Clearly incorrect zero compensation values were occasionally recorded for the A- and B-side monitors by various operators. (This problem may be the result of difficulty in reading the zero compensation scale or unfamiliarity with this measurement on the part of some monitor operators.)

(2) The apparent variation in the zero compensation values on a day-to-day basis is significant; however, a part of this apparent variation may be due to inconsistent notations regarding whether the particular values were positive or negative.

(3) For the Unit No. 1 opacity CEMS, the reported zero compensation values exceeded the suggested ± 0.018 optical density control limit on 9 days for the A-side monitor and on 5 days for the B-side monitor. Two consecutive exceedances occurred for the A-side monitor; however, in all other cases, the zero compensation values were within the suggested control limits for the following day, even though no corrective action was undertaken.

(4) For the Unit No. 2 opacity CEMS, the reported zero compensation values exceeded the suggested ± 0.018 optical density control limit on 9 days for the A-side monitor and on 10 days for the B-side monitor. All of the reported B-side monitor zero compensation values were within the suggested ± 0.018 optical density limit.

Span Checks

An upscale check of the Unit No. 1 and 2 opacity CEMS's responses is performed at least once daily using an internal span filter in conjunction with the zero mirror of the RM41. The monitoring system responses to the span check, as indicated both by the DP-30 printout and the strip charts, were recorded on the daily log. According to the draft QA procedures, corrective action was to be initiated when either of the monitor responses indicated by the DP-30 was more than ± 2.5% opacity relative to the correct value of the span filter.

The following results are indicated by the review of the tabulated span check data for Units No. 1 and 2, respectively.

Unit No. 1

(1) All of the span check responses indicated by the DP-30 were within the span control limits except for two consecutive days (10/18-19/83) when extremely small exceedances of the control limit (i.e., 0.04% and 0.03% opacity) occurred.

(2) The DP-30 span check values were generally very consistent, typically reflecting day-to-day variations of considerably less than 0.5% opacity.

(3) For the span check responses indicated by the chart recorder, 125 exceedances of the span control limit were observed; all of these exceedances reflected an apparent low bias in the recorded values. It is emphasized that no requirement for adjustment of the chart recorder calibration was included in the QA plan, since emissions data from the recorder are not used in preparing excess emissions reports. Furthermore, there is no indication that the chart recorder was adjusted at any time during the 1-year study. Of the 125 exceedances, 90 indicated a low bias of 3% opacity or less, and a total of 106 of the 125 exceedances (i.e., 85%) indicated a low bias of less than 4% opacity.

Unit No. 2

(1) All of the span check responses indicated by the DP-30 were within the ± 2.5% span drift control limit except for: (1) the two values recorded on 3/4-5/84, when power was interrupted, and (2) the value recorded on 3/12/84, when the upper limit was exceeded by 0.23% opacity.

(2) The span check values indicated by DP-30 are extremely consistent, typically reflecting day-to-day variations of considerably less than 0.5% opacity.

(3) For the span check responses indicated by the strip chart recorder, 20 exceedances of the ± 2.5% opacity span control limit were observed. Sixteen of these exceedances reflected a low bias in the values recorded by the strip chart; only four exceedances represented a positive bias. Again, criteria for adjustment of the chart recorder calibration were not included in the QA procedures for this monitor.

Based on the span check data, it is apparent that: (1) the accuracy of the monitoring data recorded by the DP-30 is consistently within ± 2.5% opacity relative to the span check value, (2) the strip chart recorder data exhibited both greater variability than the DP-30 data and a low bias relative to the span check values, and (3) the frequency and number of exceedances of the span control limits as indicated by the strip chart recorder are greater than would occur if adjustments to the recorder calibration were performed when exceedances are initially identified.

Time Required for Daily Checks

The time required to perform the daily checks of the Sioux Station opacity monitoring systems can be determined from the daily log sheets. During the 1-year study, 14 different individuals performed the daily checks on various occasions.

The time necessary to perform the daily checks typically ranged from 2 to 10 minutes, and averaged approximately 5 minutes. As individual monitor operators became more familiar with the daily check procedures, a small reduction in the amount of time needed is usually apparent. However, the average time required to perform the daily checks remained relatively constant over the duration of the project on a monthly average.

4.3.2 Periodic QA Checks

The periodic QA procedures provide for checks of monitoring system components and operational status that are unfeasible, impractical, or unnecessary on a daily basis. The periodic QA checks were intended to be performed in conjunction with the opacity CEMS routine maintenance program that is performed monthly at the Sioux Station. The periodic QA check procedures included: (1) zero/span checks of the CEMS's as indicated by the panel meter, chart recorder, and DP-30 computer system, (2) a check of the reference current, (3) verification that the AGC circuit is on, (4) a check of optical alignment of the transmissometer components, (5) determination of the zero compensation values before and after cleaning of the optical surfaces, and (6) recording of the minimum 6-minute average opacity for the 1-hour periods preceding and following the periodic QA check. The last item was included in order to attempt to quantify the dust accumulation on the optical surfaces of the transmissometer.

A total of eight periodic QA checks were performed for the Unit No. 1 CEMS, and a total of seven periodic QA checks were performed for the Unit No. 2 CEMS. Summaries of the periodic QA check results for the Unit No. 1 and 2 CEMS's are shown in Table 4-6. The results of the attempted quantification of dust accumulation that were based on the 6-minute average effluent opacity measurements before and after the QA check are not included in Table 4-6. Because of fluctuations in the effluent opacity level, these measurements did not provide a meaningful indication of the quantity of dust accumulation on the optical surfaces. The periodic QA check results support the following findings:

Unit No. 1, A- and B-Side Monitors

(1) The reference current for both the A- and B-side monitors was very stable and was consistently within the acceptable range.

(2) No exceedances of the recommended zero compensation range (i.e., ± 0.018 OD) were observed either before or after cleaning the optical surfaces of the transmissometer. Cleaning of the optical surfaces did not result in a systematic change in the zero compensation values; the changes were relatively small and seemed to fall within the noise level associated with the measurement.

TABLE 4-6
PERIODIC QA CHECK RESULTS
PORTAGE DES SIOUX, UNIT NO. 1

DATE	MONITOR	REF. CURRENT (ma)	ZERO COMP. (OD)		ZERO CHECK (% OPACITY)			SPAN CHECK (% OPACITY)			AGC (ON/OFF)	ALIGNMENT	TIME	COMMENTS
			INITIAL	FINAL	METER	CHART	DP-30	METER	CHART	DP-30				
6/22/83	1-A	19.2	0.0065	0	0	0	0.39	68.8	69	70.79	ON	O.K.	--	
	1-B	19.4	-0.015	0	8	8	8%	70	71	73.11	--	O.K.	--	(1)
7/26/83	1-A	20	-0.005	-0.011	0	0	0.54	67	68	70.95	ON	O.K.	7:40-14:20	
	1-B	19.25	0.002	-0.011	2	2	2.74	66.3	68	71.31	ON	O.K.	9:30-14:20	
9/1/83	1-A	19.5	-0.017	-0.01	0	0	-0.6	66	68	70.79	ON	O.K.	7:30-10:10	
	1-B	19.2	-0.005	-0.004	0	0	0.33	65	66	69.97	ON	O.K.	8:00-10:10	
10/14/83	1-A	19	0.007	--	0	0	0.73	66	67	70.46	ON	O.K.	8:00-14:30	(2)
	1-B	19.1	-0.006	--	0(-)	0(-)	0.15	65	66	69.88	ON	O.K.	8:35-14:30	(2)
11/22/83	1-A	19.2	40*	41*	0.0	0.5	1.12	66	69.5	71.62	ON	O.K.	7:22-10:10	
	1-B	19.4	50*	42*	--	0.5	0.48	65	68	70.37	ON	O.K.	7:22-10:10	
1/12/84	1-A	19.1	-0.011	0.012	0	0	0.64	65.5	67	71.16	ON	O.K.	7:25-10:15	
	1-B	19.1	0.013	0.013	0	0	0.09	65	67	70.82	ON	O.K.	7:36-10:15	
2/19/84	1-A	19.5	-0.01	0.0	0	0	0.67	66	68	71.34	ON	O.K.	7:45-10:15	
	1-B	19.5	-0.005	0.00	0.0	0.0	-0.12	65	66	70.34	ON	O.K.	8:05-10:15	
3/21/84	1-A	19.5	0.015	-0.01	0	0	0.48	66	66.5	71.16	ON	O.K.	8:00- --	
	1-B	18.5	0.01	-0.01	0	0	0.48	66	66.1	70.52	ON	O.K.	8:15- --	

(1) Corrective action necessary to resolve zero problem (corrective action log not yet available). Problem found to be in MON B O.D. card. The card was calibrated.

(2) Chart recorder zero response on mechanical stop; Job Request submitted.

* Operator recorder value from wrong scale on panel meter.

(TABLE 4-6, continued)
PERIODIC QA CHECK RESULTS
PORTAGE DES SIOUX, UNIT NO. 2

DATE	MONITOR	REF. CURRENT (ma)	ZERO COMP. (OD)		ZERO CHECK (% OPACITY)			SPAN CHECK (% OPACITY)			AGC (ON/OFF)	ALIGNMENT	TIME	COMMENTS
			INITIAL	FINAL	METER	CHART	DP-30	METER	CHART	DP-30				
7/7/83	2-A	19.2	0	0	0	0	0.88	69	68	71.40	ON	O.K.	7:30-9:45	(1)
	2-B	19.5	0.01	0.005	0	0	1.16	70	68	70.40	ON	O.K.	12:45-3:00	(2)
8/10/83	2-A	19.6	0	0.008	0	0	0.88	67	68	70.92	ON	O.K.	7:30-11:00	
	2-B	19.6	0.013	0.002	0	0	1.16	65.5	66	70.15	ON	O.K.	8:00-11:00	
9/21/83	2-A	19.2	0.0158	0.018	0	0.8	0.82	67	67	70.64	ON	O.K.	7:40-10:00	
	2-B	19.5	0.006	0.008	0	0.8	0.79	66	66.2	70.00	ON	O.K.	8:00-10:00	
10/25/83	2-A	19.6	0.014	0.007	0	0	0.97	67	67	70.46	ON	O.K.	7:30-13:15	
	2-B	19.8	0.014	-0.002	0	0	1.31	67	67	69.94	ON	O.K.	8:30-13:15	(3)
12/7/83	2-A	19.6	0.013	0.014	0	0	0.91	66.2	67.5	70.28	ON	O.K.	7:00-11:20	
	2-B	19.8	0.015	0.015	0	0	0.61	68.5	--	70.55	ON	O.K.	7:00-11:20	
1/24/84	2-A	19.9	0.005	0.005	0	0	0.48	68	68	69.97	ON	O.K.	8:15-12:25	
	2-B	19.8	0.007	0.001	0	0	1.03	68.5	68	70.46	ON	O.K.	8:15-12:25	
3/14/84	2-A	19.8	0.006	0	0	0	1.00	69	67	70.00	ON	O.K.	9:30-13:05	
	2-B	20.0	0.005	0	0	0	1.34	67.5	66.5	70.92	ON	O.K.	9:30-13:05	

(1) Wire disconnected for filter alarm. Wires were connected and the alarm was tested. Alarm performed properly.

(2) Wire disconneted for filter alarm. Wires were reconnected and the alarm was tested. Submitted JR #217355 for transceiver side of duct.

(3) Zero mirror lense was cracking. Replaced lense and calibrated.

(3) All of the panel meter, chart recorder, and DP-30 references fell within the ± 2.5% opacity zero drift limit except for (1) the values indicated by all three devices for the B-side monitor on 6/22/83 and (2) the DP-30 response on 7/26/83. The problem identified during the 6/22/83 periodic QA check was resolved at that time by recalibrating the optical density circuit board. The exceedance that occurred on 7/26/83 was small (i.e., the monitor response was 2.74% opacity).

(4) All of the span check responses indicated by the DP-30 were within ± 1.5% opacity of the correct value. However, many of the span check responses indicated by the panel meter and chart recorder exceeded the ± 2.5% span drift limit; a negative bias was generally observed for both of these recording devices.

(5) No problems with the automatic gain control (AGC) circuit or with the optical alignment of either of the opacity monitors were observed during any of the periodic QA checks.

Unit No. 2, A- and B-Side Monitors

(1) The reference current for both the A- and B-side monitors was very stable and was consistently within the acceptable range.

(2) No exceedances of the recommended zero compensation range (i.e., ± 0.018 OD) were observed either before or after cleaning of the optical surfaces of the transmissometers. In all but one case, cleaning of the optical surfaces reduced the zero compensation value.

(3) All of the panel meter, chart recorder, and DP-30 zero check responses were within ± 1.5% opacity; thus, the ± 2.5% opacity zero check control limit was never exceeded.

(4) All of the span check responses indicated by the DP-30 output were within ± 1.5% opacity of the correct value. However, three of the panel meter span check responses and one of the chart recorder responses exceeded the ± 2.5% opacity span check control limit. As with the Unit No. 1 monitor, the panel meter and the chart recorder data both exhibited a negative bias relative to the correct span value and to the DP-30 output.

(5) No problems with the AGC circuit or the optical alignment of either of the opacity monitors were observed during any of the periodic QA checks.

In addition, several minor problems were identified for both the Unit No. 1 and 2 opacity CEMS's during the periodic QA checks. In most cases, these problems were resolved during the periodic QA check. It can be determined from the QA records that the time required to perform the periodic QA checks ranged from approximately 2.5 to 7.5 hours.

4.3.3 Corrective Action

The corrective action procedures and log were intended to provide a general indication of what was done to resolve specific monitor problems and to document the impact of adjustments/repairs on (1) fault lamp status, (2) zero and span check responses, and (3) monitor calibration. It was intended that a corrective action log would be completed on each occasion when control limits were exceeded in either the daily or the periodic QA checks and on all other occasions when adjustments or repairs of the opacity CEMS's were performed. In general, the corrective action log required that measurements of various parameters be recorded before and after corrective action, so that the effects of the adjustments and repairs could be assessed.

Notes and comments regarding corrective action are included in the daily and periodic QA check logs. In addition, Sioux Station personnel completed corrective action logs on four occasions for the Unit No. 1 opacity CEMS, and on five occasions for the Unit No. 2 opacity CEMS. The data recorded on the corrective action logs (from the checks conducted before and after corrective action was performed) support the statements by source personnel regarding what the problem was and what was done to correct it. The following is a summary (taken directly from information provided by source personnel) of the corrective action performed for the Sioux Station opacity CEMS's during the 1-year field study:

Unit No. 1

7/21/83 - Digital/analog differential alarm activated. Problem traced to the A-side monitor. Adjustments were performed to eliminate the problem.

10/19/83 - Excessive span drift observed in daily calibration. Problem isolated to the A-side monitor and subsequently found to be caused by a defective micro switch in the transceiver.

11/2/83 - Adjusted zero offset control on opacity card. Although the voltage value was within specifications at the time the checks were performed, the zero value would occasionally drift below -0.01, thereby activating the digital/analog alarm.

12/30/83 - SHUTTER fault activated for the A-side monitor. Instrument air line [used for this monitor in place of purge air blower] was broken. [Generating unit was off-line during the period that this problem occurred and was resolved.]

Unit No. 2

7/19/83 - Repaired filter...[unreadable].... on B-side monitor.

10/14/83 - WINDOW fault indicator activated for A-side monitor. After a manual zero check was completed from the combiner unit, the problem corrected itself. The zero compensation circuit was automatically updated during the zero check. Cleaning of optical surfaces was not necessary.

12/14/83 - REFERENCE and OVER RANGE fault indicators activated; digital/analog differential alarm. Output signals from A-side monitor were lost. Found defective J-Box switch after much trouble shooting. Problems were difficult to find because switch failed intermittently (would begin working if technician tapped on J-Box meter).

1/10/84 - SHUTTER and WINDOW fault indicators activated. Problem diagnosed as bad purge air blower. Blower was replaced with one from spare parts inventory.

2/3/84 - WINDOW fault indicator activated. Abnormal calibration caused zero reflector to fall out of position. The problem was corrected immediately when a manual zero check was performed.

At the beginning of the study, the Sioux Station personnel completed all of the blanks on the corrective action log. However, as the study progressed, only those sections of the log that were directly related to the problem that was encountered were completed. Union Electric Company personnel provided revisions to the corrective action instructions and log to eliminate the need for recording unnecessary data. The Sioux Station personnel clearly demonstrated that their level of expertise was such that recording only that data directly related to the problems encountered was sufficient to facilitate expeditious and reliable corrective actions.

4.4 SOURCE SELF AUDIT

Personnel at the Sioux Station conducted performance audits of the Units No. 1 and 2 opacity CEMS's on January 26 and 27, 1984 using audit devices supplied by the project team. Source personnel had previously observed and/or participated in the initial audit, had access to the detailed report for the initial audit, and were furnished a copy of "Performance Audit Procedures for Opacity Monitors" (EPA-340/1-83-010). Using this information, the Sioux Station personnel conducted the performance audits in accordance with the prescribed procedures and completed the necessary data sheets (see Appendix B). The results that were calculated from the data provided by the source self audit are summarized in Tables 4-7 through 4-10 for the Unit No. 1 A- and B-side monitors and the Unit No. 2 A- and B-side monitors, respectively.

The following conclusions are apparent from the review of data and results obtained from the Sioux Station opacity audits:

1. The Sioux Station personnel who conducted the audit did an excellent job. All data forms were properly completed. Wherever possible, measurement values were recorded from all three data display devices for each of the opacity CEMS's (i.e., panel meter, strip chart recorder, and computer). In addition, to simulate the procedures used in the operation and maintenance of the opacity CEMS's, a digital voltmeter was used to obtain measurements which otherwise are available only at the panel meter.

2. The only procedural error identified in the audit results calculated by the Sioux Station personnel was the use of the algebraic rather than the absolute value of the mean difference in the final determination of the calibration error test results.

TABLE 4-7. SUMMARY OF PERFORMANCE AUDIT RESULTS
UNIT NO. 1, MONITOR A
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM
-SOURCE SELF AUDIT-

	Audit Result	Acceptable Result
MONITOR COMPONENT ANALYSIS		
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error:		
Combiner	0.08%	± 2%
Computer	0.00%	± 2%
Combiner Panel Meter Status:		
Opacity Scale Factor	1.05	0.98 to 1.02
Optical Density Scale Factor	0.96	0.98 to 1.02
Input Scale Factor	1.00	0.98 to 1.02
Reference Signal Analysis:		
Panel Meter	2.5%	± 10%
Digital Volt Meter	0.5%	± 10%
Internal Zero Error:		
(Chart Recorder)	0.0% Opacity	± 2% Opacity
(DP-30 Analog)	0.6% Opacity	± 2% Opacity
Internal Span Error:		
(Chart Recorder)	-1.59% Opacity	± 2% Opacity
(DP-30 Analog)	2.02% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Audit	-0.001	± 0.018 OD
After Audit	-0.006	± 0.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	ND	≤ 2% Opacity
Reflector Window	ND	≤ 2% Opacity
Total	ND	≤ 4% Opacity

(continued on next page)

Table 4-7. continued

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (17.0% Opacity):				
Panel Meter	-0.54%	0.44%	0.98%	$\leq$ 3%
Chart Recorder	0.32%	0.37%	0.69%	$\leq$ 3%
Computer	0.79%	0.19%	0.98%	$\leq$ 3%
Mid Range (38.0% Opacity):				
Panel Meter	-1.14%	0.92%	2.06%	$\leq$ 3%
Chart Recorder	-0.24%	0.54%	0.78%	$\leq$ 3%
Computer	1.53%	0.20%	1.73%	$\leq$ 3%
High Range (74.1% Opacity):				
Panel Meter	-2.21%	0.26%	2.47%	$\leq$ 3%
Chart Recorder	-0.15%	0.06%	0.21%	$\leq$ 3%
Computer	2.39%	0.11%	2.51%	$\leq$ 3%

TABLE 4-8. SUMMARY OF PERFORMANCE AUDIT RESULTS
UNIT NO. 1, MONITOR B
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM
-SOURCE SELF AUDIT-

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error:		
Combiner	0.08%	± 2%
Computer	0.00%	± 2%
Combiner Panel Meter Status:		
Opacity Scale Factor	1.06	0.98 to 1.02
Optical Density Scale Factor	1.09	0.98 to 1.02
Input Scale Factor	0.97	0.98 to 1.02
Reference Signal Analysis:		
Panel Meter	2.5%	± 10%
Digital Volt Meter	0.3%	± 10%
Internal Zero Error:		
(Chart Recorder)	0.0% Opacity	± 2% Opacity
(DP-30 Analog)	0.7% Opacity	± 2% Opacity
Internal Span Error:		
(Chart Recorder)	-3.64% Opacity	± 2% Opacity
(DP-30 Analog)	1.28% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Audit	-0.007	± 0.018 OD
After Audit	-0.007	± 0.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	ND	≤ 2% Opacity
Reflector Window	ND	≤ 2% Opacity
Total	ND	≤ 4% Opacity

(continued on next page)

Table 4-8. continued

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (17.0% Opacity):				
Panel Meter	-0.82%	0.50%	1.32%	≤ 3%
Chart Recorder	0.42%	0.22%	0.64%	≤ 3%
Computer	0.35%	0.05%	0.40%	≤ 3%
Mid Range (38.0% Opacity):				
Panel Meter	-2.02%	0.03%	2.05%	≤ 3%
Chart Recorder	-0.22%	0.34%	0.56%	≤ 3%
Computer	0.82%	0.18%	1.00%	≤ 3%
High Range (74.1% Opacity):				
Panel Meter	-3.67%	0.68%	4.34%	≤ 3%
Chart Recorder	-1.27%	0.55%	1.82%	≤ 3%
Computer	0.84%	0.38%	1.22%	≤ 3%

TABLE 4-9. SUMMARY OF PERFORMANCE AUDIT RESULTS
UNIT NO. 2, MONITOR A
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM
-SOURCE SELF AUDIT-

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error:		
Combiner	-0.95%	± 2%
Computer	0.0%	± 2%
Combiner Panel Meter Status:		
Opacity Scale Factor	1.00	0.98 to 1.02
Optical Density Scale Factor	1.01	0.98 to 1.02
Input Scale Factor	0.99	0.98 to 1.02
Reference Signal Analysis:		
Panel Meter	0.5%	± 10%
Digital Volt Meter	0.0%	± 10%
Internal Zero Error:		
(Chart Recorder)	0.0% Opacity	± 2% Opacity
(DP-30 Analog)	0.5% Opacity	± 2% Opacity
Internal Span Error:		
(Chart Recorder)	-2.19% Opacity	± 2% Opacity
(DP-30 Analog)	1.58% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Audit	0.013	± 0.018 OD
After Audit	0.013	± 0.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	ND	≤ 2% Opacity
Reflector Window	ND	≤ 2% Opacity
Total	ND	≤ 4% Opacity

(continued on next page)

Table 4-9. continued

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (17.1% Opacity):				
Panel Meter	-0.06%	0.46%	0.52%	≤ 3%
Chart Recorder	-1.12%	0.06%	1.18%	≤ 3%
Computer	0.06%	0.25%	0.31%	≤ 3%
Mid Range (38.3% Opacity):				
Panel Meter	0.07%	0.56%	0.63%	≤ 3%
Chart Recorder	-2.11%	0.22%	2.33%	≤ 3%
Computer	-0.13%	0.07%	0.20%	≤ 3%
High Range (74.4% Opacity):				
Panel Meter	-3.39%	0.01%	2.40%	≤ 3%
Chart Recorder	-3.59%	2.04%	5.63%	≤ 3%
Computer	-0.17%	0.05%	0.22%	≤ 3%

TABLE 4-10. SUMMARY OF PERFORMANCE AUDIT RESULTS
UNIT NO. 2, MONITOR B
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM
-SOURCE SELF AUDIT-

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error:		
Combiner	-0.953%	± 2%
Computer	0.00%	± 2%
Combiner Panel Meter Status:		
Opacity Scale Factor	1.02	0.98 to 1.02
Optical Density Scale Factor	1.00	0.98 to 1.02
Input Scale Factor	0.99	0.98 to 1.02
Reference Signal Analysis:		
Panel Meter	0.5%	± 10%
Digital Volt Meter	0.0%	± 10%
Internal Zero Error:		
(Chart Recorder)	0.0% Opacity	± 2% Opacity
(DP-30 Analog)	1.16% Opacity	± 2% Opacity
Internal Span Error:		
(Chart Recorder)	-3.44% Opacity	± 2% Opacity
(DP-30 Analog)	0.73% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Audit	0.00	± 0.018 OD
After Audit	0.00	± 0.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	ND	≤ 2% Opacity
Reflector Window	ND	≤ 2% Opacity
Total	ND	≤ 4% Opacity

(continued on next page)

Table 4-10. continued

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (17.1% Opacity):				
Panel Meter	0.76%	0.16%	0.92%	≤ 3%
Chart Recorder	0.60%	0.52%	1.12%	≤ 3%
Computer	0.77%	0.08%	0.85%	≤ 3%
Mid Range (38.3% Opacity):				
Panel Meter	1.11%	0.68%	1.79%	≤ 3%
Chart Recorder	-0.51%	0.27%	0.78%	≤ 3%
Computer	0.63%	0.05%	0.68%	≤ 3%
High Range (74.4% Opacity):				
Panel Meter	-0.29%	0.28%	0.57%	≤ 3%
Chart Recorder	-1.39%	0.01%	1.40%	≤ 3%
Computer	1.29%	0.01%	1.30%	≤ 3%

3. Exceedances of the "acceptable" range of audit results for the opacity, optical density, and input scale factors at the Sioux Station should be ignored, because station personnel typically use a digital voltmeter in place of the panel meter when performing adjustments of the opacity CEMS's.

4. If the status of the combiner panel meter is ignored, the Unit No. 1 A-side monitor demonstrated acceptable performance relative to all of the audit criteria.

5. If the status of the combiner panel meter is ignored, the Unit No. 1 B-side monitor demonstrated acceptable performance relative to all of the audit criteria except for (a) the internal span error as indicated by the chart recorder response (the computer response was within the acceptable range) and (b) the high range calibration error as indicated by the panel meter responses (both the chart recorder and the computer responses were within the acceptable range for this test).

6. The Unit No. 2 A-side monitor demonstrated acceptable performance for all of the audit criteria except for (a) the internal span error as indicated by the chart recorder response (the computer response was within the acceptable range) and (b) the high range calibration error as indicated by the chart recorder responses (both the panel meter and the computer responses were within the acceptable range for this test).

7. The Unit No. 2 B-side monitor demonstrated acceptable performance for all of the audit criteria except for the internal span error as indicated by the chart recorder response (the computer response was within the acceptable range).

As part of the source self audit, it was requested that a zero alignment check of the opacity monitors be performed. Procedures were suggested for conducting this test at the monitoring location. This procedure was not performed during the audit. The letter transmitting the audit results included the following statement:

> "The separate draft ZERO CHECK PROCEDURES were not tried because of physical constraints at our remote monitor locations. This type of check is performed at least once per year for all monitors as part of a bench calibration procedure performed in the controlled environment of the plant test shop."

4.5 FINAL PERFORMANCE AUDIT

A final performance audit of the Sioux Station Unit No. 2 opacity CEMS was conducted on June 7, 1984. An audit of the Unit No. 1 opacity monitoring system was not performed because of a problem evident in the DP-30 output for the Unit No. 1 monitoring system. Union Electric Company personnel agreed to conduct an audit of this monitor after the problem was resolved. Detailed discussions of the findings and results of the final audit of the Unit No. 2 opacity CEMS are included in the June 1984 audit report for this station.

The results of the final performance audit of the Unit No. 2 opacity CEMS are summarized in Tables 4-11 and 4-12 for the A- and B-side monitors, respectively. The following conclusions were derived from the results of the final audit of the Unit No. 2 CEMS:

1. The opacity monitoring system exhibited acceptable performance for all of the audit criteria evaluated during the June 1984 performance audit.
2. The analog and digital opacity values included in the DP-30 printout are equivalent within ± 2% opacity.
3. The Unit No. 2 opacity monitoring system was accurately calibrated and very well maintained (as indicated by the lack of any detectable dust accumulation on optical surfaces) at the time the audit was performed.
4. The procedure of determining the panel meter scale factors and internal zero and span errors simultaneously for the A- and B-side monitors by leaving both monitors in service and the analyzer select switch in the "Exit" position (a) is simpler than determining the same parameters for both monitors individually, (b) more closely approximates how plant personnel view the monitor in daily calibration checks, and (c) should be an adequate check of these parameters for determining whether a significant problem with the monitor exists.

A final performance audit of the Sioux Station Unit No. 1 CEMS was conducted on June 29, 1984 by Union Electric Company personnel after the resolution of the problem that was evident in the DP-30 output at the time of the final audit of the Unit No. 2 monitor. Detailed discussions of the final audit results for the Unit No. 1 CEMS are included in a memorandum dated February 25, 1985.

The results of the final performance audit of the Unit No. 1 opacity CEMS are summarized in Tables 4-13 and 4-14 for the A- and B-side monitors, respectively. The following conclusions were derived from the results of this audit:

1. The A-side opacity monitor exhibited acceptable performance for all of the audit criteria evaluated.
2. The B-side opacity monitor exhibited acceptable performance for all of the audit criteria evaluated except for the mid range calibration error as indicated by the chart recorder responses. (Both the analog and the digital responses of the computer printout were within the acceptable limits for this test.)
3. The Sioux Station personnel performing the audit omitted those checks that are already included in daily operating procedures (e.g., zero compensation checks) or routine operating procedures/periodic QA checks (e.g., dust accumulation on optical surfaces).
4. The personnel performing the audit omitted the determination of the combiner unit panel meter scale factors, because the panel meter is not used by station personnel for either opacity or optical density measurements.

TABLE 4-11. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS
UNIT NO. 2, MONITOR A
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	Not Determined	± 2%
Combiner Panel Meter Status:		
Opacity Scale Factor (Exit)[1]	0.995	0.98 to 1.02
Optical Density Scale Factor (Exit)[1]	0.990	0.98 to 1.02
Reference Signal Analysis	-0.5%	± 10%
Internal Zero Error (Chart)	0.0% Opacity	± 2% Opacity
Internal Zero Error (DP-30)	0.48% Opacity	± 2% Opacity
Internal Span Error (Exit)[2] (Chart)	-0.17% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Cleaning	-0.003 OD	±.018 OD
After Cleaning	-0.002 OD	±.018 OD

Optical Surface Dust Accumulation:

	Analog	Digital	
Transceiver Window	0.0%	0.0% Opacity	≤ 2% Opacity
Reflector Window	-0.5% (0.0%)	-0.5% Opacity (0.0%)	≤ 2% Opacity
Total	-0.5% (0.0%)	-0.5% Opacity (0.0%)	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (17.1% Opacity)				
Analog	-0.24%	0.30%	0.54%	≤ 3%
Digital	-0.80%	0.31%	1.11%	≤ 3%
Mid Range (38.3 Opacity)				
Analog	-0.04%	0.33%	0.36%	≤ 3%
Digital	-1.11%	0.61%	1.72%	≤ 3%
High Range (74.4% Opacity)				
Analog	2.07%	0.07%	2.14%	≤ 3%
Digital	-0.09%	0.00%	0.09%	≤ 3%

(continued on next page)

Table 4-11. continued

[1] Opacity and optical density panel meter scale factors determined for the combiner (i.e., both Monitor A and Monitor B simultaneously) by comparison of panel meter response for the "Exit" condition to the correct value.

[2] Internal span error determined for the combiner (i.e., Monitor A and Monitor B simultaneously) by comparison of the chart recorder for the "Exit" condition to the correct value.

TABLE 4-12. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS
UNIT NO. 2, MONITOR B
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	Not Determined	± 2%
Combiner Panel Meter Status:		
Opacity Scale Factor (Exit)[1]	0.995	0.98 to 1.02
Optical Density Scale Factor (Exit)[1]	0.990	0.98 to 1.02
Reference Signal Analysis	+0.5%	± 10%
Internal Zero Error (Chart)	0.0% Opacity	± 2% Opacity
Internal Zero Error (DP-30)	0.52% Opacity	± 2% Opacity
Internal Span Error (Exit)[2] (Chart)	-0.17% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Cleaning	-0.003 OD	±.018 OD
After Cleaning	-0.003 OD	±.018 OD

Optical Surface Dust Accumulation:

	Analog	Digital	
Transceiver Window	0.0% (0.0%)	0.0% Opacity	≤ 2% Opacity
Reflector Window	-0.37% (0.0%)	0.0% Opacity	≤ 2% Opacity
Total	-0.34% (0.0%)	0.0% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (17.1% Opacity)				
Analog	-0.57%	0.08%	0.65%	≤ 3%
Digital	-1.94%	0.00%	1.94%	≤ 3%
Mid Range (38.3 Opacity)				
Analog	-0.54%	0.06%	0.60%	≤ 3%
Digital	-2.06%	0.14%	2.20%	≤ 3%
High Range (74.4% Opacity)				
Analog	1.75%	0.04%	1.79%	≤ 3%
Digital	-0.49%	0.00%	-0.49%	≤ 3%

(continued on next page)

Table 4-12. continued

[1] Opacity and optical density panel meter scale factors determined for the combiner (i.e., both Monitor A and Monitor B simultaneously) by comparison of panel meter response for the "Exit" condition to the correct value.

[2] Internal span error determined for the combiner (i.e., Monitor A and Monitor B simultaneously) by comparison of the chart recorder for the "Exit" condition to the correct value.

TABLE 4-13. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS
UNIT NO. 1, MONITOR A
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	?[1]	On
Stack Exit Correlation Error	ND[2]	± 2%
Combiner Panel Meter Status:		
Opacity Scale Factor	ND	0.98 to 1.02
Optical Density Scale Factor	ND	0.98 to 1.02
Reference Signal Analysis	0.0%	± 10%
Internal Zero Error (Chart)	0.0% Opacity	± 2% Opacity
Internal Zero Error (DP-30 Analog)	-0.7% Opacity	± 2% Opacity
Internal Span Error (Chart)	-1.11% Opacity	± 2% Opacity
Internal Span Error (DP-30 Analog)	+1.49% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Audit	+ 0.005 OD	± 0.018 OD
After Audit	+ 0.005 OD[3]	± 0.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	ND	≤ 2% Opacity
Reflector Window	ND	≤ 2% Opacity
Total	ND	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS[4]

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (17.0% Opacity):				
Chart Recorder	-1.3%	0.2%	1.5%	≤ 3%
Analog	-0.2%	0.0%	0.2%	≤ 3%
Digital	-0.2%	0.0%	0.2%	≤ 3%
Mid Range (38.0 Opacity):				
Chart Recorder	-2.4%	0.2%	2.6%	≤ 3%
Analog	-0.2%	0.1%	0.3%	≤ 3%
Digital	-1.3%	0.1%	1.3%	≤ 3%
High Range (74.1% Opacity):				
Chart Recorder	-1.7%	0.3%	2.0%	≤ 3%
Analog	2.1%	0.0%	2.1%	≤ 3%
Digital	-0.2%	0.1%	0.2%	≤ 3%

(continued on next page)

Table 4-13. continued

[1] The AGC lamp status was checked as "OFF" on the data sheet. Since the monitor performed well in the calibration error test (which would not be expected if the AGC circuit was malfunctioning), and since extensive experience has shown that the AGC circuit of the LSI RM-41 rarely malfunctions, it is believed that the reported "OFF" status is the result of confusion regarding the performance audit procedures. The "OFF" position reflects proper monitor operation for all of the fault lamp indicators included on the combiner unit. However, proper monitor operation is indicated when the AGC LED on the transceiver is illuminated (i.e., "ON"). It is currently believed that the person performing the audit reported the AGC circuit lamp as "OFF" to indicate proper monitor performance.

[2] ND means "not determined" during the audit.

[3] There is no indication that the optics were cleaned or that a zero check of the monitor was performed after the initial zero compensation reading was obtained. Thus, the "After Audit" zero compensation value should be the same as the "Before Audit" value, and it is. In this case, the "After Audit" value provides no additional information and can be disregarded.

[4] Calibration error results are reported for (a) the strip chart responses, (b) the analog responses obtained from the DP-30 printout, and (c) the digital responses obtained from the DP-30 printout. The opacity values associated with the low, mid, and high range tests are reported as the audit filter values corrected to stack exit conditions. Those cases where the sum of the mean error and 95% confidence interval do not appear to equal the calibration error are due to rounding errors. (See attached calculations.)

TABLE 4-14. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS
UNIT NO. 1, MONITOR B
UNION ELECTRIC COMPANY, PORTAGE DES SIOUX STATION
LEAR SIEGLER OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	?[1]	On
Stack Exit Correlation Error	ND[2]	± 2%
Combiner Panel Meter Status:		
Opacity Scale Factor	ND	0.98 to 1.02
Optical Density Scale Factor	ND	0.98 to 1.02
Reference Signal Analysis	0.0%	± 10%
Internal Zero Error (Chart)	0.0% Opacity	± 2% Opacity
Internal Zero Error (DP-30 Analog)	-0.42% Opacity	± 2% Opacity
Internal Span Error (Chart)	-0.61% Opacity	± 2% Opacity
Internal Span Error (DP-30 Analog)	0.94% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Audit	+ 0.004 OD	± 0.018 OD
After Audit	ND[3]	± 0.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	ND	≤ 2% Opacity
Reflector Window	ND	≤ 2% Opacity
Total	ND	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS[4]

	Mean Error (Opacity)	95% CI (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (17.0% Opacity):				
Chart Recorder	-0.7%	1.3%	1.9%	≤ 3%
Analog	-0.4%	0.3%	0.7%	≤ 3%
Digital	-0.5%	0.1%	0.6%	≤ 3%
Mid Range (38.0 Opacity):				
Chart Recorder	-2.5%	0.9%	3.4%	≤ 3%
Analog	-1.4%	0.2%	1.6%	≤ 3%
Digital	-1.8%	0.1%	1.9%	≤ 3%
High Range (74.1% Opacity):				
Chart Recorder	-2.2%	0.3%	2.5%	≤ 3%
Analog	-0.3%	0.7%	1.0%	≤ 3%
Digital	-0.7%	0.1%	0.8%	≤ 3%

(continued on next page)

Table 4-14. continued

[1] The AGC lamp status was checked as "OFF" on the data sheet. Since the monitor performed well in the calibration error test (which would not be expected if the AGC circuit was malfunctioning), and since extensive experience has shown that the AGC circuit of the LSI RM-41 rarely malfunctions, it is believed that the reported "OFF" status is the result of confusion regarding the performance audit procedures. The "OFF" position reflects proper monitor operation for all of the fault lamp indicators included on the combiner unit. However, proper monitor operation is indicated when the AGC LED on the transceiver is illuminated (i.e., "ON"). It is currently believed that the person performing the audit reported the AGC circuit lamp as "OFF" to indicate proper monitor performance.

[2] ND means "not determined" during the audit.

[3] There is no indication that the optics were cleaned or that a zero check of the monitor was performed after the initial zero compensation value was obtained. No value is provided for the "After Audit" zero compensation value on the attached data sheets.

[4] Calibration error results are reported for (a) the strip chart responses, (b) the analog responses obtained from the DP-30 printout, and (c) the digital responses obtained from the DP-30 printout. The opacity values associated with the low, mid, and high range tests are reported as the audit filter values corrected to stack exit conditions. Those cases where the sum of the mean error and 95% confidence interval do not appear to equal the calibration error are due to rounding errors. (See attached calculations.)

4.6 CEMS DOWNTIME

Figure 4-5 illustrates the total CEMS downtime for the Sioux Station, Units No. 1 and 2, as reported in excess emission reports from the first quarter of 1980 through the second quarter of 1984. The data for 1980 through 1982 were obtained from summaries prepared by the Missouri DNR; the data for 1983 and 1984 were obtained from a detailed review of quarterly reports submitted by Union Electric Company to the Missouri DNR. (See " An Analysis of Opacity CEMS Downtime in Excess Emission Reports: Opacity CEM Pilot Project," May 1986, for additional discussions and comparative results for other sources.)

As can be seen in Figure 4-5, CEMS downtime for both the Sioux Station opacity CEMS's was maintained below 10% of the hours in the quarter for each reporting period during 1983 and 1984 except for the second quarter of 1984 for Unit No. 1. Thus, even though the Sioux Station opacity CEMS's represent a far more complex monitoring application than is used at most sources (i.e., two monitors per unit, analog combiner system, and digital computer), the levels of CEMS availability were generally greater than 93%.

A review of the CEMS downtime information included in excess emission reports shows that the vast majority of problems resulting in CEMS downtime were resolved in less than 10 hours (10 hours corresponds to approximately 0.5% downtime). The problems that more significantly impacted monitor availability were as follow:

Unit No. 2

First Quarter 1983

- 59 hours: Combiner shut down by mistake.
- 88 hours: Bus outage (i.e., power failure) on 2 occasions.

First Quarter 1984

- 76 hours: Bus outage (i.e., power failure) on 3 occasions.
- 20 hours: Computer not calculating results.

Second Quarter 1984

- 48 hours: Computer stopped; replaced I/O circuit board.

Unit No. 1

Second Quarter 1984

- 18 hours: Replace optical density circuit board and recalibrated.
- 192 hours: Optical density circuit board defective; waiting on parts.
- 48 hours: Computer stopped; replaced I/O circuit board after trying to reprogram computer.

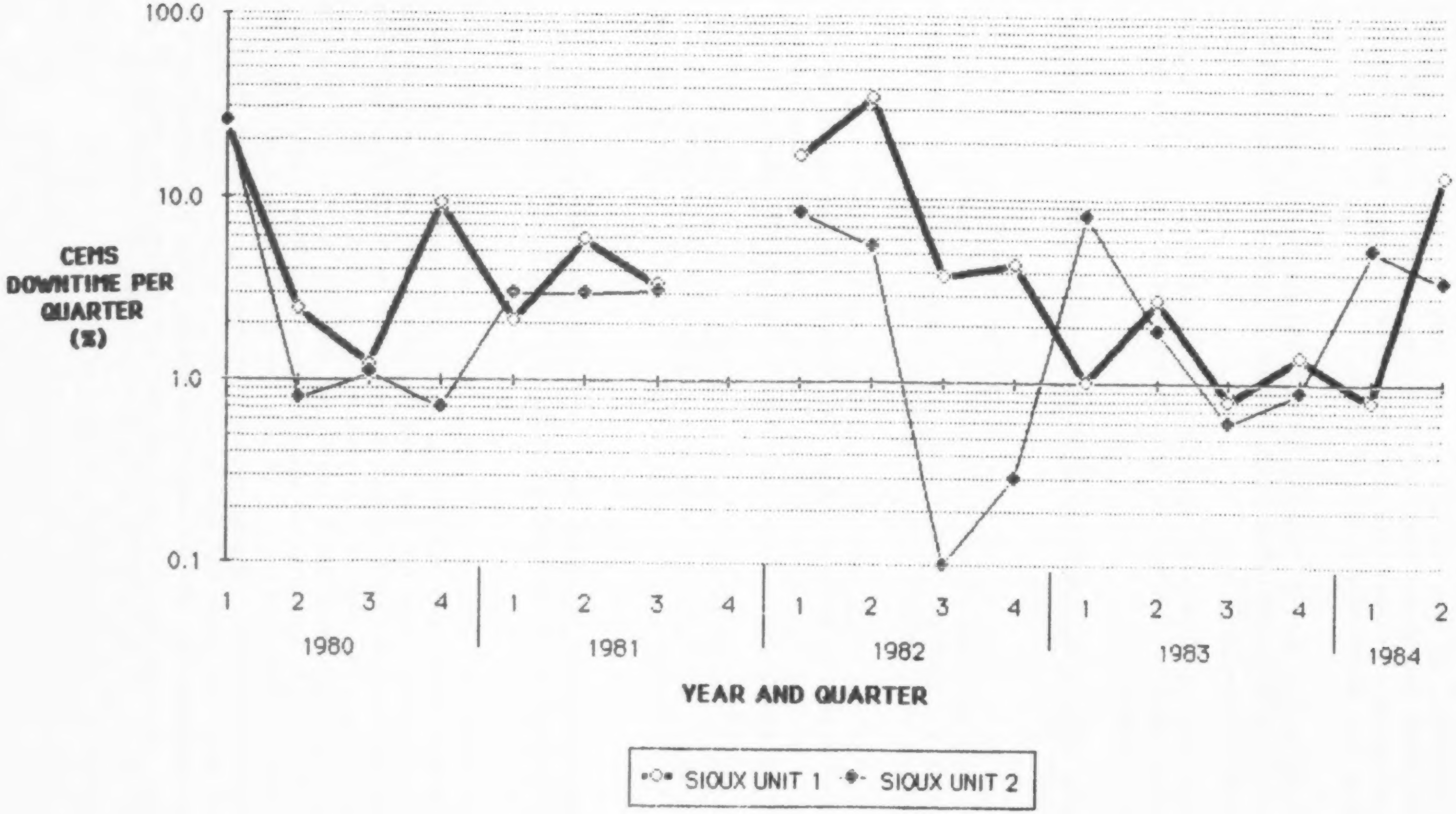


FIGURE 4-5. CEMS DOWNTIME - UNION ELECTRIC COMPANY, SIOUX STATION UNITS 1 AND 2

4.7 CONCLUSIONS

The evaluation of the results obtained from the performance audits and from the implementation of quality assurance procedures shows that reliable opacity monitoring data are provided by the two LSI opacity CEMS's installed at Union Electric Company's Portage Des Sioux Station, Units No. 1 and 2. Specific conclusions regarding monitor performance and the effectiveness of the QA procedures used during the study are provided below.

1. Despite the complexity of the opacity CEMS's installed on Units No. 1 and 2, both CEMS's achieved high levels of availability during the study (i.e., greater than 96%).

   (These availability results are expressed relative to the total number of hours in each quarter, since the opacity CEMS's are operated even during boiler outages.)

2. The LSI opacity CEMS's at the Sioux Station provide precise and accurate effluent opacity measurements.

   - For both the Unit No. 1 and 2 opacity CEMS's, virtually all of the daily zero and span checks were within the ± 2.5% opacity control limits during the entire 1-year study as indicated by the responses of the primary data recording system (i.e., the DP-30).

   - The accuracy of both the Unit No. 1 and 2 opacity CEMS's was consistently within ± 3% opacity as indicated by calibration error checks based on the responses of the primary data recording system for all three performance audits conducted during the study.

   - A zero alignment check is performed at least once per year for each monitor in order to establish the equivalency of the monitor responses to the clear-path condition and to the transceiver mirror.

3. The strip chart recorder provides data of sufficient accuracy and precision to be used as a back-up recording device during computer outages.

   (Based on the daily and periodic QA check data and on the results of the performance audits that were conducted, it is apparent that the data displayed by the chart recorder are less accurate and less precise than the data recorded by the DP-30 computer system. However, for both the Unit No. 1 and 2 opacity CEMS's, the daily and periodic QA data show that the chart recorder and DP-30 responses usually differ by less than 2% opacity. The three performance audits show that the responses of both devices were correct within ± 5% opacity as indicated by the observed mean differences. The accuracy and precision of the chart recorder data would be improved and would remain within control limits if checks and adjustments of the chart recorders were performed on a routine basis. Such checks and adjustments are recommended only if the chart recorders are to be used as back-up recording devices during computer outages.)

4. The purge air system is properly operated and maintained, and the frequency of cleaning exposed optical surfaces is sufficient to maintain measurement errors resulting from dust accumulation on optical surfaces within less than 4% opacity.

   (No exceedances of the 4% opacity dust accumulation limit were observed in either the initial or the final performance audit. [The level of dust accumulation was usually below the minimum detectable limit during the audits.] Very few exceedances of the zero compensation control limit (i.e., ± 0.018 or ± 4% opacity) are apparent in the daily logs; some of the recorded exceedances are obviously due to reading/recording errors. The WINDOW fault lamp was never activated for either the A- or B-side monitors of the Unit No. 1 opacity CEMS, and was infrequently activated for the Unit No. 2 opacity CEMS. When the WINDOW fault was activated, the problem was often resolved simply by manually initiating a zero check; other problems were expeditiously resolved by appropriate corrective action.)

5. The combiner fault lamps and the flags and error messages provided by the computer data acquisition system are effective indicators of monitor operational problems.

   (The appropriate fault lamp indicators were activated when problems were encountered for both the Unit No. 1 and 2 opacity CEMS's. The activation of the fault lamps and the presence of flags and/or error messages in the DP-30 printout were found to be consistent with the other data that were recorded. Conversely, extraneous fault indicators and/or computer messages were not observed when no problems existed.)

6. Periodic QA checks and performance audits are effective for the identification of monitor operational problems that may otherwise be overlooked.

   (The periodic QA checks for the Unit No. 1 CEMS resulted in the identification of problems (1) in the B-side monitor optical density circuit board, and (2) in the chart recorder zero response. For the Unit No. 2 CEMS, problems with the filter alarm and the zero mirror were identified. For both the Unit No. 1 and 2 CEMS's, differences between the chart recorder and DP-30 span check responses were identified; however, these were not subsequently corrected, because the chart recorders are not used as back-up recording devices.)

7. Sioux Station personnel have clearly demonstrated the necessary expertise and capability to operate and maintain the installed opacity CEMS's properly.

   (Prior to the 1-year study, station personnel had developed successful solutions for most of the previously encountered monitoring problems. During the study, station personnel completed the daily and periodic QA checks and provided numerous suggestions for improving these procedures. Station personnel clearly demonstrated that they are able to determine the cause of monitor problems and that they could accomplish all necessary corrective action quickly and properly. They also successfully conducted complex performance audits of the opacity CEMS's using procedures that provided a comprehensive and representative indication of monitor performance. As evidenced by the results obtained at the Sioux Station and by interviews conducted before and after the study period, source personnel thoroughly understand how the CEMS works and take pride in achieving successful monitor performance.)

5.0 KANSAS CITY POWER AND LIGHT COMPANY, IATAN STATION

This section provides relevant background information and a summary and discussion of results obtained from both (1) the implementation of quality assurance procedures and (2) the performance audits of the installed opacity CEMS at Kansas City Power and Light Company's Iatan Station. An overview of the field study conducted for this unit is provided in Figure 5-1.

5.1 SOURCE AND MONITOR DESCRIPTIONS

5.1.1 Source Description

Iatan Unit No. 1 (the only unit at Iatan) is a coal-fired electric utility steam generator equipped with Lodge Cottrell electrostatic precipitators (ESP's) for control of particulate emissions. The unit is rated at approximately 630-700 MW and burns low sulfur Western coal. Iatan Unit No. 1 is subject to the requirements of 40 CFR 60 "Subpart D - Standards of Performance for Fossil-Fuel-Fired Steam Generators for Which Construction is Commenced After August 17, 1971."

5.1.2 Monitor Description

The Lear Siegler, Inc. (LSI) RM41 opacity monitoring system utilized at the Iatan Station consists of a single transmissometer (transceiver and retroreflector), a monitor control unit, and a strip chart recorder. The transmissometer is installed within the annular space between the stack shell and liner at approximately 280 feet above grade in the exhaust stack (see Figure 5-2). The opacity monitor measurement path passes through the centroid of the stack cross-section. The only means of access to the monitoring location is a series of ladders installed in the annular space between the stack wall and the stack liner.

The monitor control unit is mounted on the rear of the instrument panel in the boiler control room. Six-minute average opacity levels are displayed on a strip chart recorder located on the front of the instrument panel. The strip chart recorder is the only automatic recording device used with the opacity monitoring system; however, the boiler operators also maintain an hourly log of effluent opacity measurements as displayed by the control unit panel meter. The log also contains notations regarding periods of excess emissions (i.e., periods when the 6-minute average opacity exceeds 20%). These periods are included in quarterly reports submitted to the Missouri Department of Natural Resources.

5.2 INITIAL AUDIT

An initial audit of the opacity CEMS installed at Iatan Station was performed on March 8-9, 1983. The audit included (1) a visual evaluation of the monitor installation location, (2) a systems audit (i.e., a qualitative evaluation of monitor operation, maintenance, and record keeping practices), and (3) a performance audit of the opacity CEMS (i.e., a quantitative evaluation of monitor accuracy and precision). Detailed discussions of the findings and results of the initial audit are included in the March 1983 audit report for this station.

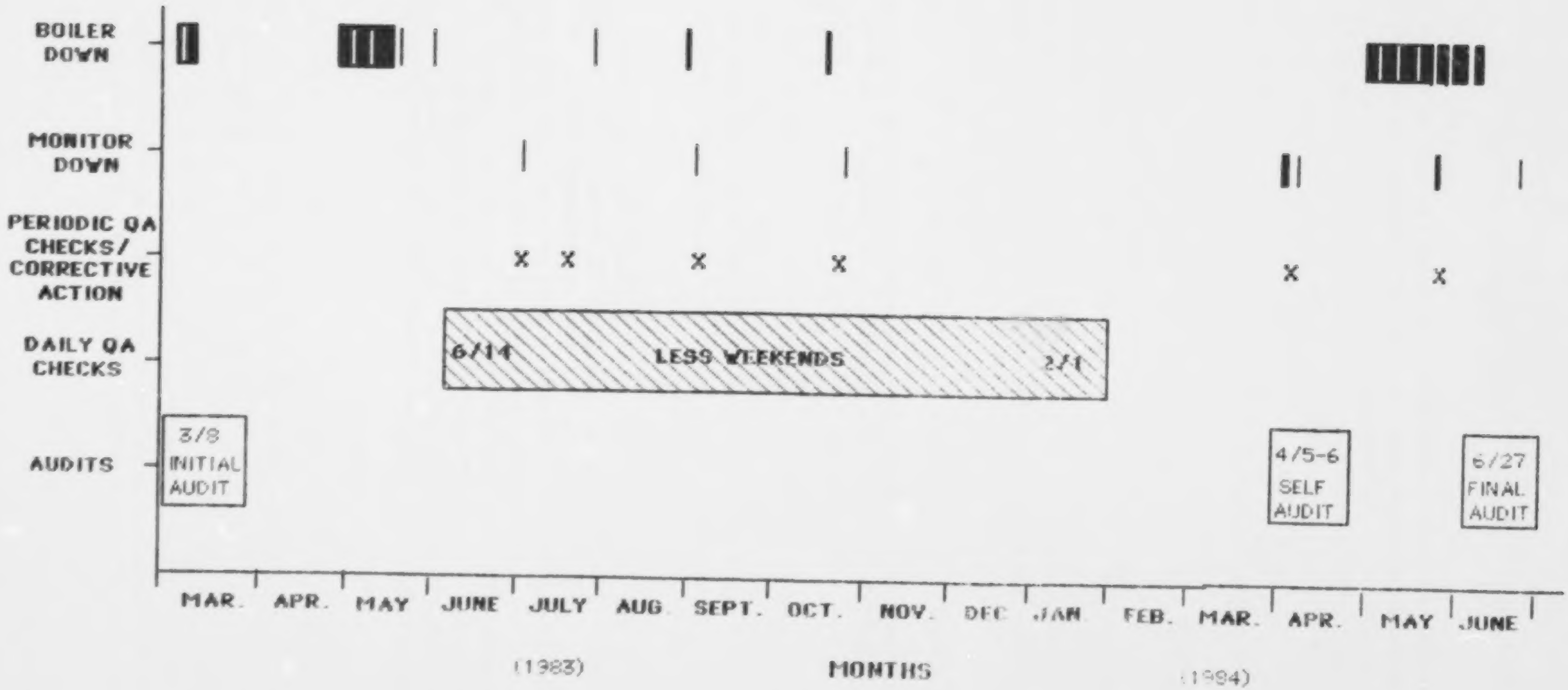


FIGURE 5-1. KANSAS CITY POWER & LIGHT COMPANY IATAN STATION: OPACITY CEMS PROJECT

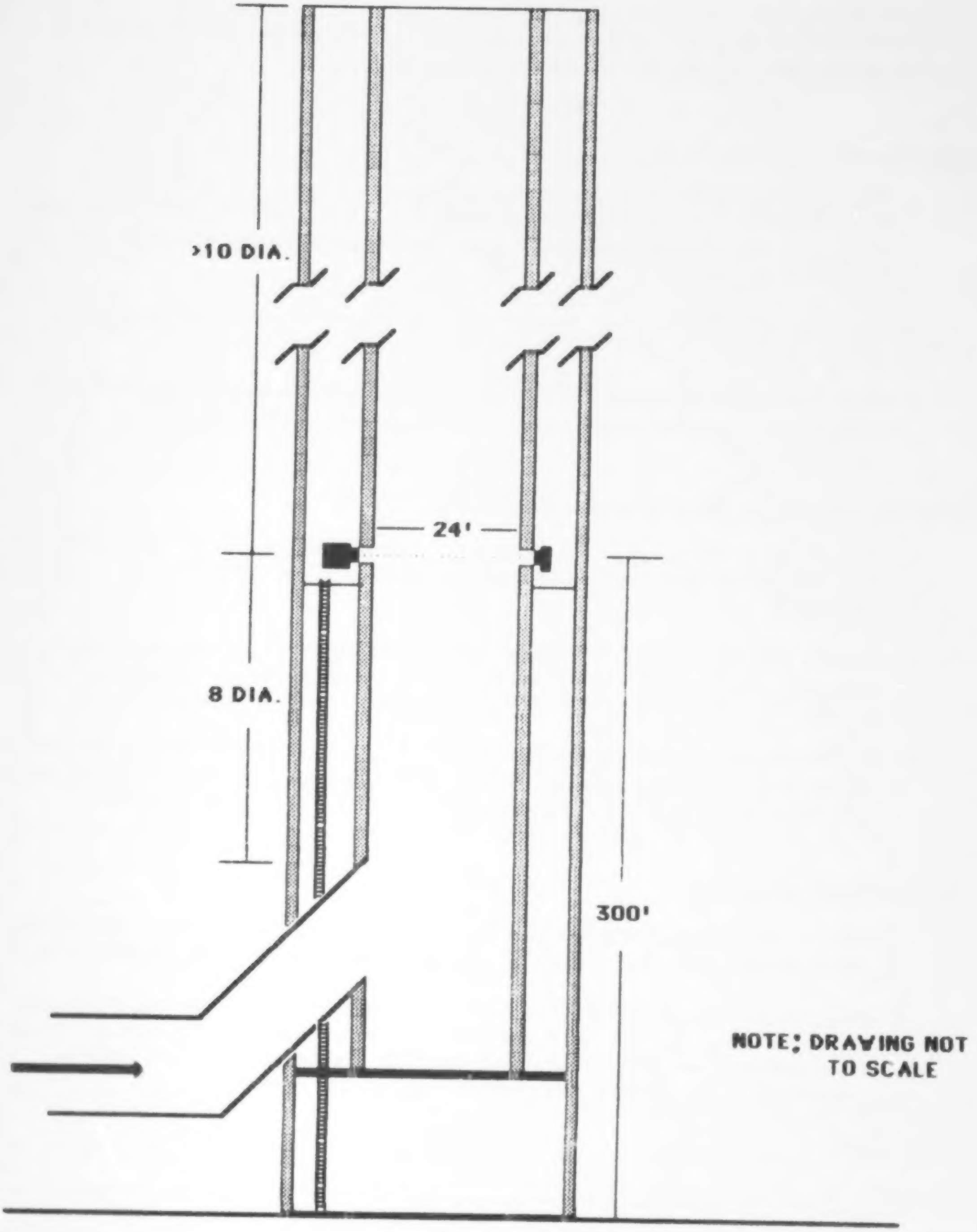

>10 DIA.
24'
8 DIA.
300'
NOTE; DRAWING NOT TO SCALE

FIGURE 5-2. IATAN OPACITY MONITORING LOCATION

The results of the initial performance audit of the Iatan opacity CEMS are summarized in Table 5-1. The following conclusions were derived from the initial audit of the opacity monitoring system.

Monitor Installation Location

1. The opacity CEMS is installed in accordance with Performance Specification 1, Appendix B, 40 CFR 60. The installation location provides opacity measurements that are representative of the entire effluent stream.

2. The opacity CEMS is not subject to any known adverse environmental conditions.

3. The difficult access to the installed transmissometer impacts the frequency of conducting monitor maintenance activities.

Monitor Operation, Maintenance, and Record Keeping

1. The opacity CEMS operates reliably. High levels of monitor availability are achieved, and infrequent adjustment of zero and/or span values is required.

2. Successful solutions for previously encountered monitor problems have been devised by source personnel (e.g., installation of a lightning protection device, resolution of circuit board problems, etc.).

3. Significant effluent opacities are sometimes present during boiler outages. The existence of the residual opacity prohibits conducting an on-stack clear-path calibration check of the opacity monitor.

Monitor Performance

1. The Iatan opacity monitoring system was found to exhibit acceptable performance for all criteria evaluated during the performance audit.

2. The slight degree of optical misalignment observed during the audit may have been due to the unit outage. (The alignment of the monitor should be checked when the generating unit is operating and the stack temperature is within the normal operating range.)

TABLE 5-1. SUMMARY OF INITIAL PERFORMANCE AUDIT RESULTS
KANSAS CITY POWER AND LIGHT COMPANY, IATAN UNIT NO. 1
LEAR SIEGLER MODEL RM41 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	0%	± 2%
Control Panel Status:		
Opacity Scale Factor	1.01	0.98 to 1.02
Optical Density Scale Factor	0.98	0.98 to 1.02
Reference Signal Analysis	1.0%	± 10%
Internal Zero Error	0.0% Opacity	± 2% Opacity
Internal Span Error	0.1% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Borderline	Yes
Zero Compensation:		
Before Cleaning	.000 OD	± .018 OD
After Cleaning	-.001 OD	± .018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	0.9% Opacity	≤ 2% Opacity
Reflector Window	1.1% Opacity	≤ 2% Opacity
Total	2.0% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS	Mean Error (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (9.0% Opacity)			
Panel Meter	-0.3%	0.5%	≤ 3%
Strip Chart	-1.0%	---	
Mid Range (20.5% Opacity)			
Panel Meter	-0.5%	0.5%	≤ 3%
Strip Chart	-1.4%	---	
High Range (51.5% Opacity)			
Panel Meter	-1.4%	1.5%	≤ 3%
Strip Chart	-2.3%	---	

5.3 QUALITY ASSURANCE PROCEDURES

Draft quality assurance procedures were developed for the Iatan opacity CEMS. The QA procedures consisted of daily checks, periodic QA procedures, and criteria and general procedures for use in performing corrective action for the opacity CEMS. During the initial audits of the opacity CEMS, additional information was obtained which allowed for revision of the draft QA procedures. (A copy of the QA procedures utilized during the study is included in Appendix C of this report.) Implementation of the QA procedures began on June 19, 1983. Based on a review of the QA data obtained during the first 8 months of the field study, recommendations for revisions to the QA procedures were developed. The following section provides a brief description of the QA procedures, a summary of the QA data, and a discussion of the results of implementing the QA program.

5.3.1 Daily QA Checks

The daily check procedures involve only simple checks of monitor operation that can be performed at the monitor control unit. The purpose of these checks is to determine whether the opacity CEMS is apparently operating properly or if corrective action is necessary. For the LSI RM41 opacity CEMS at Iatan, these procedures involved: (1) a check of whether fault lamps were illuminated, (2) recording of the reference current, (3) a check of the zero compensation value, and (4) zero and span checks for both the panel meter and the strip chart recorder. The time required to perform the QA checks was also noted on the daily log. An example daily log is shown in Figure 5-3.

Monthly summaries of all of the daily QA check results from June 14, 1983 until February 1, 1984 are included in Appendix C of this report. These summaries contain all of the information recorded on the daily logs in a condensed format. A review of the monthly summaries shows that many of the daily checks were not performed. For the first 2 months of the study, station personnel completed the daily log each day. However, after this initial period, the frequency of the daily QA checks was continuously reduced: 12 daily logs were completed for November; 10 daily logs were completed for December; and 6 daily logs were completed for January 1984. Based on a review of the data recorded in the daily logs for the first 8 months of the QA implementation, the pilot project team agreed with the practices adopted by the Iatan Station personnel and recommended that the checks previously scheduled to be conducted on a daily basis be performed instead only on a weekly basis.

Fault Lamp Indicators

The RM41 opacity monitor is equipped with five fault lamps which, when illuminated, indicate operational problems with the monitor. These fault lamps and brief explanations of their functions are as follow:

(1) REF - Indicates when reference current level is outside of acceptable range.

Opacity Monitoring System

DAILY LOG

KANSAS CITY POWER AND LIGHT IATAN STATION

I. GENERAL INFORMATION

Name:____________________ Date: ____________ Time Start: ___________

Time Complete:___________

Hours Boiler Down: _____________ Hours Monitor Down: ___________

II. FAULT LAMPS

FAULT LAMPS ON?	NO	YES
Filter		
Shutter		
Ref		
Windows		
Over Range		

III. PANEL METER DATA

"REF" value (ma): ________________________

Zero Compensation (OD): _________________

	NO	YES
Does "REF" value exceed acceptable range (17.9-22.2 ma)?		
Does "ZERO COMP" exceed acceptable range (± .018 OD)?		

IV. STRIP CHART DATA

Zero Calibration (% opacity):_________________________

Span Calibration (% opacity):_________________________

	NO	YES
Does zero value exceed acceptable limits of ± 2.0% opacity?		
Does span value exceed acceptable limits (32.5 ± 2.0% opacity?)		

IF YES ANSWERS ARE INDICATED FOR ANY OF THE ABOVE QUESTIONS, CORRECTIVE ACTION SHOULD BE INITIATED AS SOON AS POSSIBLE.

V. COMMENTS:

FIGURE 5-3. EXAMPLE OPACITY CEMS DAILY LOG: KANSAS CITY POWER & LIGHT COMPANY, IATAN STATION

(2) WINDOW	- Indicates when zero compensation and, thus, dust accumulation on the transceiver optics exceeds acceptable range.
(3) OVER RANGE	- Indicates that measurement value exceeds selected optical density range.
(4) SHUTTER	- Indicates that the protective shutter has been inserted into the light path to protect the monitor from the effluent.
(5) FILTER	- Indicates a problem with purge air system.

Only one occasion was noted on the daily log sheets when a fault lamp was illuminated during the 8 month period for which QA data were reviewed. On this occasion (7/2/83), the REF fault lamp was illuminated. The reference current at this time was 18.3 ma, which is within the acceptable range of 17.9 to 22.2 ma. The notes on the daily log sheet indicate that station personnel replaced a transceiver circuit board and returned the monitor to proper operation at 1530 on 7/2/83, approximately 7-1/2 hours after the problem was first detected. The daily check data for the following day, 7/3/83, also indicated that proper monitor operation had been restored.

Reference Current Checks

For the LSI RM41 CEMS, the reference current signal is used for comparison with the measurement current signal to determine the transmittance and, thus, the opacity of the effluent. The accuracy of the opacity measurement is therefore directly dependent on the accuracy and the stability of the reference current signal over time. Because of the importance of this parameter, recording of the reference signal level was included in the daily QA procedures. Acceptable performance is indicated when the reference signal level falls within the range of 17.9 to 22.2 ma, according to the manufacturer; reference signals outside these control limits indicate the need for corrective action.

The RM41 reference current signal was consistently within the specified control limits during the study. On the one occasion described above, a REF fault occurred when the reference current was observed to be 18.3 ma. However, all of the other reported reference current values were within the range of 19.8 to 20.5 ma, which is less than 25 percent of the allowable range recommended by the manufacturer. Therefore, for the Iatan monitor, the reference current appears to be very stable, and the REF fault lamp has been observed to be activated before the applicable control limits are reached.

Zero Checks

A check of the opacity monitoring system's response at the zero opacity level is performed at least once per day using the RM41 zero mirror to simulate clear path conditions. The monitor response to this check as indicated by the panel meter and on the strip chart was recorded on the daily log. According to the QA procedures, adjustment of the monitor was to be performed when the monitor response exceeded ± 2% opacity during the zero check.

For the strip chart records, no exceedances of the ± 2% opacity zero control limits were indicated during the field study. The zero check response as indicated by the panel meter exceeded the ± 2% opacity limit on only one occasion (7/19/83), when a value of 2.2% opacity was recorded. (The value indicated on the strip chart for the same day was 2.0% opacity.) The only corrective action taken with respect to the zero check values occurred on 9/24/83, when the mechanical zero on the panel meter was reset to eliminate a high bias of 1% opacity.

Zero Compensation Checks

The LSI RM41 opacity monitor is equipped with a zero compensation feature which automatically adjusts the measured opacity value to compensate for dust accumulation on the exposed optical surfaces of the transceiver unit. According to the draft QA procedures, cleaning of the optical surfaces should be performed when the level of zero compensation exceeds ± 0.018 optical density (i.e., ± 4% opacity).

For the data recorded at the Iatan Station, zero compensation values ranged from -0.005 to +0.016 optical density (i.e., within acceptable limits) on all except for two occasions when exceedances of the ± 0.018 optical density control limit were indicated. One of the two exceedances occurred on 7/2/83 and is attributable to the problem with the reference current level which occurred on the same day. The second exceedance of the zero compensation control limit was recorded on 12/4/83 (0.07 optical density). This value is probably due to an error either in reading the panel meter or in recording the result, since both the preceding and subsequent zero compensation levels are recorded as 0.009 optical density.

The daily QA check zero compensation data for the Iatan Station indicate that (1) the zero compensation feature appears to function properly, and (2) cleaning of the exposed surfaces of the transceiver is performed with sufficient frequency to maintain the level of zero compensation within the range of ± 0.018 optical density. No corrective action was initiated at any time during the study in response to the zero compensation values.

Span Checks

An upscale check of the opacity monitor's response is performed once daily using an internal span filter and the zero mirror of the RM41. The monitor response to the span check as indicated by both the panel meter and the strip chart was recorded on the daily log. According to the QA procedures, adjustment of the monitor was to be performed when the monitor response exceeded ± 2% opacity relative to the correct value of the span filter (i.e., 32.5% opacity).

The span check values obtained from the panel meter ranged between 31.0 and 33.5% opacity on all except for three occasions. The three occasions when the ± 2% opacity span value control limit was exceeded were: (1) on the first day of the QA implementation (6/14/83), when a value of 30% opacity was recorded; (2) on 7/2/83, when the reference fault was activated; and (3) on 10/25/83, when a value of 30.2% opacity was recorded. Based on the available data, it is not possible to determine if the apparent exceedances of the span control limit indicated by the panel meter on 6/14/83 and 10/25/83 were due to reading/recording errors or to actual drift problems with the monitor. Nevertheless, the values recorded for these days indicate a low bias, and the two values exceeded the control limit by only 0.5% opacity and 0.3% opacity, respectively.

For the span check values obtained from the strip chart record, only two exceedances of the ± 2% opacity span control limit were noted. These values occurred: (1) on 7/2/83, when the reference fault lamp was activated; and (2) on 10/25/83 (the same day an exceedance of the span control limit was indicated by the panel meter), when a span check value of 30.2% opacity was recorded. All other span values were within the QA control limits.

Based on the span check data, it is concluded that: (1) the accuracy of the monitor calibration at the span check value is consistently within ± 2% opacity in all except for extremely rare instances when a low bias may be observed; and (2) the panel meter and the strip chart record provide an adequate and consistent indication of monitor performance relative to the daily span checks.

Time Required for Daily Checks

The time required to perform the daily checks of the Iatan Station opacity monitoring system can be determined from the daily log sheets. Six different individuals performed the daily checks on various occasions during the first 8 months of the QA procedure implementation. Four of these people performed checks at the very beginning of the QA implementation period (i.e., 6/14-30/83). The time necessary to perform the daily checks during this period ranged from 3 to 13 minutes and averaged 7.1 minutes. As the monitor operators became more experienced, a reduction in the amount of time necessary to perform the daily checks is apparent from the tabulated data. The time required to perform the daily checks during December 1983 and January 1984 ranged from 1 to 6 minutes and averaged 4.3 minutes. This represents a reduction of nearly 40% in the average time required to perform the daily check procedure over the 8 month period during which the QA procedures were implemented.

5.3.2 Periodic QA Checks/Corrective Action

The periodic QA procedures provide for checks of monitoring system components and operational status that are unfeasible, impractical, or unnecessary on a daily basis. These checks were intended to be performed in conjunction with the routine preventive maintenance program that is performed three times per year at Iatan. The periodic QA check procedures included: (1) zero and span checks of both the panel meter and the chart recorder, (2) checks of the reference current and zero compensation values, (3) a check of the AGC circuit, (4) a check of the optical alignment of the transmissometer components, (5) a check of the purge air system status, and (6) a determination of the apparent dust accumulation on the optical surfaces.

According to station personnel, all of these checks except for the determination of dust accumulation on optical surfaces were already included in the routine maintenance program. (Window cleaning was included in the routine maintenance program.)

Statements by station personnel indicated that the difficult access to the monitor installation location (300-foot ladder) was a major consideration in the performance of maintenance activities for the monitor. Routine maintenance activities are roughly scheduled to be performed only three times per year, and non-rountine maintenance is peformed only as it is indicated necessary by problems observed at the monitor control unit. Whenever a problem occurs that requires a trip to the monitoring location, all monitor maintenance activities and a complete system check-out are performed in order to avoid a separate trip for routine maintenance. Thus, the routine maintenance schedule remains very flexible to take advantage of corrective action activities and because of other factors, such as (1) weather conditions (climbing the ladder is avoided during all of winter and whenever there is a chance of thunderstorms), and (2) availability of instrument technicians.

Because of the factors described above, the periodic QA check and corrective action procedures were substantially modified at the Iatan Station. Although periodic QA check logs and corrective action logs were not received with the other QA documentation reviewed for the pilot project, these activities were delineated in quarterly reports submitted to the Missouri DNR. The following list describes the periodic QA and corrective action procedures performed at the Iatan Station during the 1-year study.

Date	Activity	CEM Downtime
7/2/83	REF lamp illuminated. Replaced RM41 transceiver circuit board and cleaned transmissometer windows.	5.5 hours
7/11/83	Replaced plugged purge air system filters.	1 hour
9/2/83	Replaced integrator circuit board in opacity monitor control unit and recorder amplifier circuit board in chart recorder.	5.1 hours
10/10/83	Replaced purge air system filters and performed preventive maintenance for transmissometer.	5 hours
4/5-6/84	Removed monitor from stack and peformed off-stack zero check and clear-path audit.	28.2 hours
4/9/84	Performed on-stack audit checks.	3.2 hours
5/25-26/84	Optical density circuit board failure in monitor control unit. Replaced circuit board.	29 hours

As can be seen from the above activities, the primary problem affecting opacity CEMS performance at the Iatan Station was the failure of circuit boards, both in the transceiver and in the monitor control unit. However, station personnel have demonstrated that they are able to resolve these problems in an expeditious fashion.

5.4 SOURCE SELF AUDIT/OFF-STACK ZERO CHECK

Personnel at the Iatan Station conducted an off-stack zero check and audit of the opacity CEMS on April 5-6, 1984 using audit devices supplied by the project team. Source personnel had previously observed and/or participated in the initial audit, had access to the detailed report for the initial audit, and were furnished a copy of "Performance Audit Procedures for Opacity Monitors" (EPA-340/1-83-010). Station personnel removed the transmissometer from its installed location and set up the transceiver and reflector in their laboratory, using the same separation distance for the monitor components as is used when the monitor is installed on the stack. Proper zero alignment was established (i.e., equivalency of the monitor responses to the clear path condition and to the zero mirror). Station personnel conducted the performance audit of the opacity monitor in the laboratory generally in accordance with the prescribed procedures and completed the necessary data sheets (see Appendix C). However, since the audit was performed off-stack, some of the parameters normally included in a performance audit were not evaluated. On-stack checks of the opacity CEMS were reported to have been made on April 9, 1984, after the monitor was reinstalled at the monitoring location.

The results that were calculated from the data provided by the source self audit are summarized in Table 5-2. The results of this audit show that the Iatan opacity CEMS met all of the audit criteria evaluated during the off-stack tests. It should be noted that only two measurements for each of the three filters were obtained for the calibration error test, instead of the five measurements normally obtained. Therefore, it is not possible to determine the confidence interval or the calibration error (i.e., the sum of the mean difference and confidence interval) for the monitor. In view of the very small mean errors which were observed at the low, mid, and high range levels, it is expected that the CEMS would have passed the calibration error test at all three levels if the five measurement repetitions had been performed.

5.5 FINAL PERFORMANCE AUDIT

A final performance audit of the Iatan opacity CEMS was conducted on June 27, 1984. During the final audit, station personnel indicated that no adjustments to the opacity CEMS and no QA checks had been performed since the May 6-25, 1984 boiler overhaul outage, and that several other brief outages resulting from boiler problems had occurred after the overhaul. The final performance audit marked the end of the 1-year field study at Iatan. Detailed discussions of the findings and results of this audit are included in the June 1984 audit report for this station.

The results of the final performance audit of the Iatan opacity CEMS are summarized in Table 5-3. The following conclusions were derived from the performance audit results:

1. The opacity monitoring system exhibited acceptable performance for most of the criteria evaluated during the performance audit.
2. Readings obtained from the control unit panel meter are biased low relative to readings obtained from the strip chart record.

TABLE 5-2. SUMMARY OF PERFORMANCE AUDIT RESULTS
KANSAS CITY POWER AND LIGHT COMPANY, IATAN
LEAR SIEGLER MODEL RM41 OPACITY MONITORING SYSTEM
- SOURCE SELF AUDIT -

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	Not Determined	± 2%
Panel Meter Status:		
Opacity Scale Factor	1.00	0.98 to 1.02
Optical Density Scale Factor	1.00	0.98 to 1.02
Reference Signal Analysis	0.0%	± 10%
Internal Zero Error	-0.1% Opacity	± 2% Opacity
Internal Span Error	-0.0% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS[1]		
Monitor Alignment (Centered)	Yes (Off-Stack)	Yes
Zero Compensation:		
Before Cleaning	NA	± 0.018 OD
After Cleaning	NA	± 0.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	NA	≤ 2% Opacity
Reflector Window	NA	≤ 2% Opacity
Total	NA	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS[2]

	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (8.5% Opacity)	0.0%	ND	ND	≤ 3%
Mid Range (23.0 Opacity)	-0.5%	ND	ND	≤ 3%
High Range (47.5% Opacity)	-0.75%	ND	ND	≤ 3%

---

[1] The performance audit checks were performed off-stack immediately after a recalibration and zero alignment of the monitor. These procedures require establishing proper monitor alignment, cleaning of optics, and resetting the monitor's zero value and primary calibration. Measurements of these parameters during the off-stack audit are not applicable.

[2] Only two measurements per audit filter were made. Therefore, the confidence interval and calibration error results cannot be determined.

TABLE 5-3. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS KANSAS CITY POWER AND LIGHT COMPANY, IATAN UNIT NO. 1 LEAR SIEGLER MODEL RM41 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Filter	Off	Off
Shutter	Off	Off
Reference Signal	Off	Off
Window	Off	Off
Over Range	Off	Off
AGC Circuit Status	On	On
Stack Exit Correlation Error	0%	± 2%
Panel Meter Status:		
Opacity Scale Factor	1.10	0.98 to 1.02
Optical Density Scale Factor	1.10	0.98 to 1.02
Reference Signal Analysis	0.05%	± 10%
Internal Zero Error	-1.0% Opacity	± 2% Opacity
Internal Span Error	-2.4% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Zero Compensation:		
Before Cleaning	0.025 OD	± 0.018 OD
After Cleaning	0.014 OD	± 0.018 OD
Optical Surface Dust Accumulation:		
Transceiver Window	0.0% Opacity	≤ 2% Opacity
Reflector Window	0.05% Opacity	≤ 2% Opacity
Total	0.05% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS	Mean Error (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (9.0% Opacity)			
Strip Chart	+0.04%	0.11%	≤ 3%
Mid Range (20.5% Opacity)			
Strip Chart	-1.92%	2.41%	≤ 3%
High Range (51.5% Opacity)			
Strip Chart	-4.54%	4.65%	≤ 3%
Second Filter Set Check			
Low (8.5% Opacity)	-0.4%	NA	NA
Mid (19.0% Opacity)	-2.5%	NA	NA
High (44% Opacity)	-4.0%	NA	NA

3. The internal span error exceeded the ± 2% span drift control limit included in the QA procedures.

4. As indicated by the calibration error test results, the monitor exhibits an increasing negative bias with increasing effluent opacity.

5. The monitor's responses to the internal span check and the calibration error checks are consistent. Thus, adjustment of the monitor to eliminate the internal span error would eliminate the observed calibration bias at high effluent opacity conditions.

5.6 CEMS DOWNTIME

Figure 5-4 illustrates the opacity CEMS downtime for Iatan as reported in excess emission reports from the second quarter of 1981 through the second quarter of 1984. The data for 1981 and 1982 were obtained from summaries prepared by the Missouri DNR; the data for 1983 and 1984 were obtained from a detailed review of quarterly reports submitted by Kansas City Power and Light to the Missouri DNR. (See " An Analysis of Opacity CEMS Downtime in Excess Emission Reports: Opacity CEM Pilot Project," May 1986, for additional discussions and comparative results for other sources.)

As can be seen from Figure 5-4, CEMS downtime decreased from a value of approximately 20% (450 hours), for the first quarter that data were reported, to a minimum level, which was consistently below 3% (65 hours), for all subsequent reporting periods. Thus, the opacity CEMS at Iatan achieved very high levels of monitor availability (i.e., greater than 97% during the entire field study). Almost all of the very minimal CEM downtime that occurred during the field study was due to malfunctioning circuit boards and to the off-stack zero check that was performed during April of 1984.

5.7 CONCLUSIONS

The evaluation of the results obtained from the performance audits and from the implementation of quality assurance procedures shows that reliable opacity monitoring results are provided by the LSI RM41 opacity CEMS installed at Kansas City Power and Light Company's Iatan Station. Specific conclusions regarding monitor performance and the effectiveness of QA procedures are provided below.

1. The LSI opacity CEMS installed at Iatan achieved high levels of monitor availability during the study (i.e., greater than 97% for each calendar quarter).

   (These availability results are expressed relative to the total number of hours in each calander quarter, since the opacity CEMS is operated even during boiler outages.)

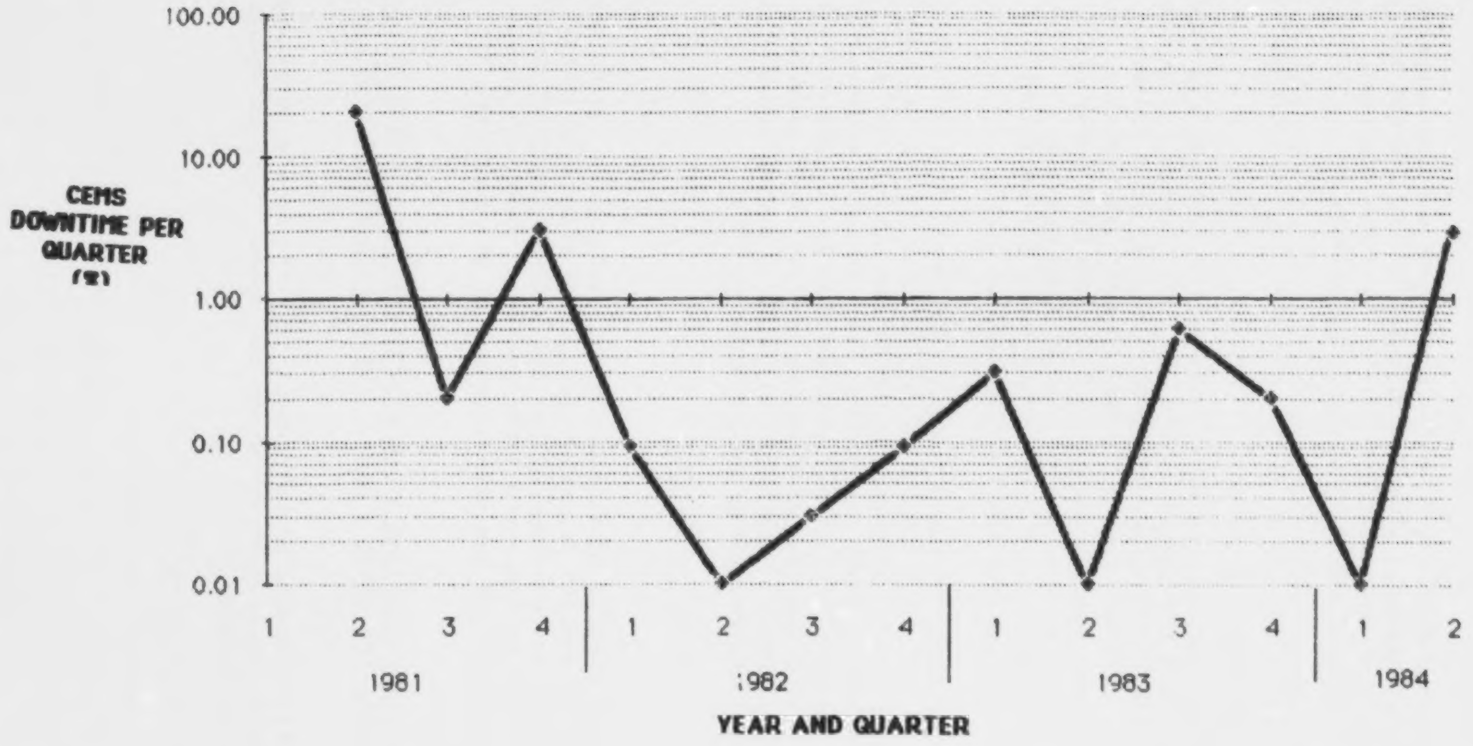


FIGURE 5-4. CEMS DOWNTIME - KANSAS CITY POWER AND LIGHT COMPANY, IATAN STATION

2. The LSI opacity CEMS is capable of providing precise and accurate effluent opacity measurements.

   - A review of 8 months of data shows that all of the daily zero check results and all except two of the daily span check results were within ± 2% opacity of the correct value.

   - The accuracy of the opacity CEMS was consistently within ± 5% opacity as indicated by calibration error check results for three performance audits conducted during the study. The calibration error results exceeded 3% opacity only during the final audit and only for the high range test. This exceedance would not have occurred if adjustments had been made to eliminate the - 2.4% opacity span error that was observed during the audit.

   - A zero alignment check was performed during the study in order to establish the equivalency of the monitor responses to the clear-path condition and to the transceiver zero mirror.

3. Adequate protection for and sufficient cleaning of exposed optical surfaces are provided to maintain measurement errors due to dust accumulation on optical surfaces to within + 4% opacity.

   (All but two of the recorded zero compensation values were within the applicable control limit, and the WINDOW fault lamp was never illuminated during the 8-month period. The initial and final audit results show that the total dust accumulation on optical surfaces was equivalent to less than 2% opacity.)

4. Weekly checks of some monitor parameters that were initially included in the daily QA check procedures are sufficient to maintain the opacity CEMS within control limits at Iatan.

   (The time required to perform daily QA checks during the study typically averaged 4 to 7 minutes. Reference current values were found to be very stable, and the REF fault indicator was observed to be illuminated before the reference current control limits specified by the manufacturer were reached. Virtually all of the zero compensation values recorded during the 8-month period were within the control limit. Zero and span check responses indicated by the panel meter and chart recorder provided consistent indications of monitor performance. These results show that both the checks of the reference current and the zero compensation values as well as the comparison of the panel meter and chart recorder responses are only necessary on a weekly basis. Daily performance of zero and span checks of the chart recorder responses is required by the applicable regulations, and thus should continue to be performed. Fault indicators should be checked at least once each day.)

5. The difficult access to the monitor installation location significantly impacts the frequency and scheduling of maintenance and periodic QA check activities for the opacity CEMS. Station personnel have developed adequate and effective maintenance practices that minimize the number of trips to the monitoring location.

   (A 300-foot ladder provides access to the monitoring location. Routine/preventive maintenance activities are scheduled to be conducted only three times per year. The routine maintenance schedule remains flexible to allow performance of these activities when unplanned trips to the monitor are necessary. According to plant personnel, a complete system check-out is performed during each trip to the monitoring location. Performance of monthly QA checks is neither practical nor necessary at Iatan.)

6. Station personnel have developed effective procedures for resolving the most frequently encountered monitor-related problems at Iatan (i.e., failure of electronic components within the opacity CEMS.)

   (Problems in the transceiver circuit board, the integrator and optical density circuit boards of the control unit, and the chart recorder amplifier board required the replacement of these components at various times during the 1-year study. An adequate inventory of source parts is maintained, and station personnel have demonstrated their capability to perform necessary repairs so that CEMS downtime is minimal.)

6.0 ST. JOSEPH LIGHT AND POWER COMPANY, LAKE ROAD STATION, UNIT NO. 5

This section provides relevant background information and a summary and discussion of results obtained from both (1) the implementation of quality assurance procedures and (2) the performance audits of the installed opacity CEMS at St. Joseph Light and Power Company, Lake Road Station, Unit No. 5. An overview of the field study conducted for this unit is provided in Figure 6-1.

6.1 SOURCE AND MONITOR DESCRIPTIONS

6.1.1 Source Description

Lake Road Unit No. 5 is a coal-fired electric utility steam generator equipped with an electrostatic precipitator for control of particulate emissions. Unit No. 5 is capable of producing the same amount of steam as a boiler rated at approximately 25 MW. However, since Unit No. 5 is connected to a common steam header with all other boilers at the Lake Road Station except Unit No. 6, and since steam produced by Unit No. 5 is supplied to local industries, a specific MW production rate is not applicable. Unit No. 5 is subject to a Missouri opacity limit of 20%.

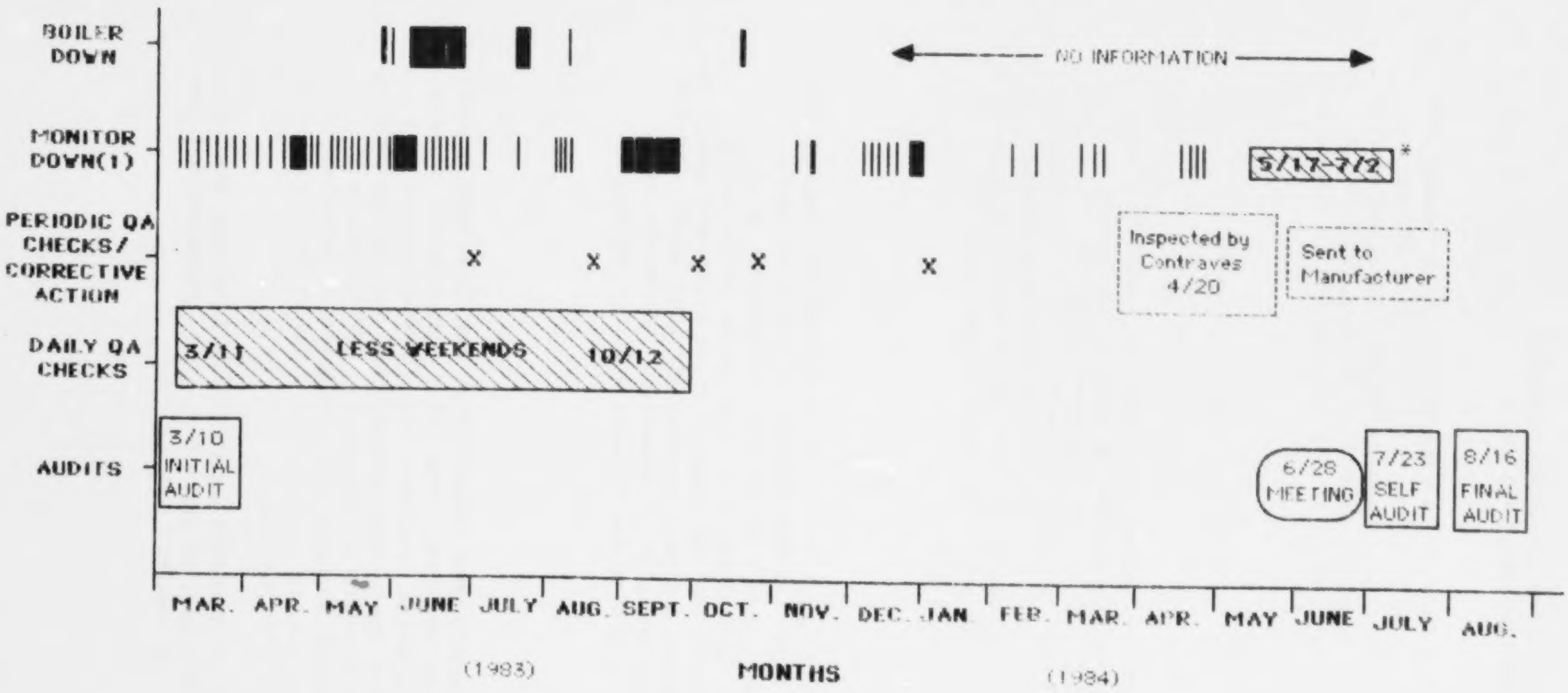
6.1.2 Monitor Description

The Contraves Goerz Model 400 opacity monitoring system utilized at Lake Road Unit No. 5 consists of a single transmissometer (transceiver and reflector), a monitor control unit, and a strip chart recorder. The transmissometer is installed at approximately 85 feet above grade in the exhaust stack. The monitor control unit is mounted on an instrument panel in the boiler control room. Normally, 6-minute average effluent opacity levels are displayed on the control unit strip chart recorder. The strip chart recorder is the only automatic recording device used with the opacity monitoring system.

3.2 INITIAL AUDIT

An initial audit of the opacity CEMS installed at the Lake Road Station Unit No. 5 was performed on March 10, 1983. The audit included (1) a visual evaluation of the monitor installation location, (2) a systems audit (i.e., a qualitative evaluation of monitor operation, maintenance, and record keeping practices), and (3) a performance audit of the opacity CEMS (i.e., a quantitataive evaluation of monitor accuracy and precision). Detailed discussions of the findings and results of the initial audit are included in the March 1983 audit report for this station.

The results of the initial performance audit of the Lake Road Station Unit No. 5 opacity CEMS are summarized in Table 6-1. The following conclusions were derived from the initial audit:



(1) Monitor downtime includes all instrument malfunctions, integrator problems and chart recorder downtime (see Section 6.6).

*Monitor shipped to manufacturer for repairs.

FIGURE 6-1. ST. JOSEPH LIGHT & POWER COMPANY, LAKE ROAD UNIT NO. 5: OPACITY CEMS PROJECT

TABLE 6-1. SUMMARY OF INITIAL PERFORMANCE AUDIT RESULTS
ST. JOSEPH LIGHT AND POWER COMPANY, LAKE ROAD, UNIT NO. 5
CONTRAVES GOERZ MODEL 400 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Dirty Window	Off	Off
Stack Power	On	On
Stack Exit Correlation Error	0%	± 2%
Control Panel Meter Correction Factor	1.01	0.98 to 1.02
Internal Zero Error	0.0% Opacity	± 2% Opacity
Internal Span Error	0.0% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	2.0% Opacity	≤ 2% Opacity
Reflector Window	0.5% Opacity	≤ 2% Opacity
Total	2.5% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (9.0% Opacity)			
Panel Meter	-2.4%	----	≤ 3%
Strip Chart	-3.3%	3.6%	
Mid Range (20.5% Opacity)			
Panel Meter	-3.2%	----	≤ 3%
Strip Chart	-3.6%	3.9%	
High Range (51.5% Opacity)			
Panel Meter	-2.0%	----	≤ 3%
Strip Chart	-2.1%	2.4%	

Monitor Installation Location

1. The opacity CEMS is installed in accordance with the provisions of Performance Specification 1, Appendix B, 40 CFR 60. The measurement location provides opacity measurements that are representative of the entire effluent stream.
2. The opacity CEMS is not subject to any known adverse environmental conditions except for the moisture and dust emitted from the nearby steam vent on the ash handling system.
3. The access provided for the opacity CEMS is adequate.

Monitor Operation, Maintenance, and Record Keeping

1. Maintenance/calibration activities for the opacity CEMS were performed on 18 occasions during the 2-year period preceding the audit.
2. Although the opacity CEMS achieves relatively high levels of availability, uncertainty regarding the accuracy of the monitor calibration increases the level of maintenance efforts required and reduces the usefulness of the monitoring data, according to plant personnel.

Monitor Performance

1. The Lake Road Unit No. 5 opacity monitoring system was found to exhibit acceptable performance for all criteria evaluated during the performance audit except for calibration error.
2. The results of the calibration error test show that the opacity CEMS data are biased low by more than 3% opacity in the 9-21% opacity range and that the bias decreases to about 2% opacity at the 51% opacity range.

6.3 QUALITY ASSURANCE PROCEDURES

Draft quality assurance procedures were developed for the Lake Road Unit No. 5 opacity CEMS. The QA procedures consisted of daily checks, periodic QA procedures, and criteria and general procedures for use in performing corrective action for the opacity CEMS. During the initial audit of the opacity CEMS, additional information was obtained that allowed for revision of the draft QA procedures. (A copy of the QA procedures utilized during the study is included in Appendix D of this report.) Implementation of the QA procedures began on March 11, 1983, which was the day following the initial audit of the opacity CEMS. Based on a review of the QA data obtained during the first 7 months of the field study, recommendations for revisions to the QA procedures were developed. The following section provides a brief description of the QA procedures, a summary of the QA data, and a discussion of the results of implementing the QA program.

6.3.1 Daily QA Checks

The daily check procedures involve only simple checks of monitor operation that can be performed at the monitor control unit. The purpose of these checks is to determine whether the opacity CEMS is apparently operating properly or if corrective action is necessary. For the Contraves Goerz Model 400 opacity CEMS at the Lake Road Station, these procedures involved: (1) a check of whether fault lamps were illuminated and (2) zero and span checks of the opacity CEMS. For the first few months, zero and span check responses for both the chart recorder and the panel meter were recorded during the daily checks; subsequently, recording of the panel meter responses was discontinued. The daily log was designed so that the time required to perform the QA checks, as well as the boiler and monitor downtime during the preceding 24-hour period, would both be recorded on the daily log. An example daily log is shown in Figure 6-2.

Summaries of all of the daily QA check results from March 11, 1983 until October 12, 1983 are included in Appendix D of this report. These summaries contain all of the information recorded on the daily logs in a condensed format. With very few exceptions, the daily log sheets were completed each day, including those periods during which the boiler was not operating.

Fault Lamp Indicators

The Contraves Goerz Model 400 opacity monitor installed at the Lake Road Station Unit No. 5 is equipped with two fault lamps that are used to indicate operational problems with the monitor:

1. STACK POWER - Indicates when electrical power is interrupted at the monitoring location.
2. WINDOW - Indicates when dust accumulation on the transceiver optics exceeds the acceptable range.

During the approximate 7-month period for which daily QA check logs are available, there were eight occasions, totalling 16 days, when the WINDOW fault lamp was illuminated. In some additional cases, the daily logs are confusing, since the various people who completed the logs used different conventions for recording the status of fault indictors. The frequency with which the WINDOW fault was activated shows that either (1) the purge air system does not adequately protect the exposed optical surfaces of the transceiver from contamination, or (2) the fault system is not an accurate indicator of the condition of the transceiver window.

Zero Checks

A check of the opacity monitoring system's response at the zero opacity level is performed at least once per day using the zero portion of the rotating transceiver chopper to simulate clear path conditions. For the first 4 months of the study, the monitor zero check responses indicated by both the panel meter and the strip chart were recorded on the daily log. For the last 3 months of the 7-month period, only the responses of the chart recorder were noted. According to the QA procedures, adjustment of the monitor was to be performed when the monitor response exceeded ± 2% opacity during the zero check.

Opacity Monitoring System

DAILY LOG

ST. JOSEPH LIGHT AND POWER CO. LAKE ROAD STATION, UNIT #5

I. GENERAL INFORMATION

Name:____________________ Date: ___________ Time Start: ___________

Time Complete:___________

Hours Boiler Down: _____________ Hours Monitor Down: ___________

II. FAULT LAMPS

FAULT LAMPS ON?	NO	YES
Stack Power		
Dirty Window		

III. STRIP CHART DATA

Zero Calibration (% opacity):_________________________

Span Calibration (% opacity):_________________________

	NO	YES
Does zero value exceed acceptable limits of ± 2.0% opacity?		
Does span value exceed acceptable limits of ± 2.0% opacity?		

IF YES ANSWERS ARE INDICATED FOR ANY OF THE ABOVE QUESTIONS, CORRECTIVE ACTION SHOULD BE INITIATED AS SOON AS POSSIBLE.

IV. COMMENTS:

FIGURE 6-2. EXAMPLE OPACITY CEMS DAILY LOG: ST. JOSEPH LIGHT & POWER COMPANY, LAKE ROAD STATION

For the 7-month period for which data are available, the zero check response as indicated by the panel meter never exceeded the ± 2% opacity limit. However, since some of the operators recorded negative zero drift as "-0" or "below zero" on the daily logs, no determination of whether excessive negative drift occurred is possible.

For the chart recorder, only one exceedance of the ± 2% opacity zero control limit occurred during the 7-month period; on 6/27/83 the chart recorder zero response was noted as + 4% opacity. The same zero check response was recorded in a periodic QA check conducted on 6/30/83; corrective action was initiated on the same day and completed on 7/1/83. The zero response was recorded as "-1.5" on 7/2/84.

The review of the daily log revealed many notations such as "+0" and "-0." Such entries were assumed to represent relatively insignificant variations around the indicated value, since any other assumption would prohibit interpretation of the data. However, it is recognized that the mechanical limit of the chart recorder in conjunction with the lack of a positive zero offset prohibited an accurate quantification of negative zero drift for the chart recorder at Lake Road Unit No. 5.

Span Checks

An upscale check of the opacity monitor response is performed once daily using the span portion of the rotating transceiver chopper. The monitor responses to the span check as indicated by both the panel meter and the chart recorder were entered on the daily log for the first 4 months of the 7-month period. Only the response indicated by the chart recorder was noted for the last 3 months. According to the QA procedures, adjustment of the monitor was to be performed when the chart recorder response exceeded ± 2% opacity relative to the correct value for the span check. At the beginning of the 7-month period, the correct value of the span check was assumed to be 64% opacity.

Prior to mid-June, the panel meter span check values ranged between 62% and 66% opacity on all except for two occasions. The two occasions when exceedances of the ± 2% opacity span drift limit occurred were the second and third days of the QA implementation (3/12-13/83), when a value of 61% opacity was recorded. This span check value (1) indicates a low bias of the monitor and (2) exceeds the control limit by 1.0% opacity.

Prior to mid-June, the chart recorder span check values indicated only one exceedance of the ± 2% opacity span control limit. This value occurred on 5/2/83, when 67% opacity was recorded. However, no corrective action was initiated to resolve this problem. All other span values were within the control limits until 6/23/83.

Beginning 6/23/83, a slight shift in the monitor calibration is apparent. Both the panel meter and the chart recorder responses to the calibration check were biased low by 3-4% opacity. A periodic QA check/corrective action were initiated on 6/30 and completed on 7/1/83 to resolve both (1) the indicated window fault condition, and (2) the zero check responses that exceeded the control limit. Several adjustments to the monitor were performed at this time, and although the exact nature of these adjustments and their impact on the monitor are unclear, it appears that after these actions, the typical monitor response to the span check was 62% opacity. It should be noted that this is the same span check value that had been used until two days prior to the initial audit of the monitor (in March of 1983).

A "correct" span check value of 62% opacity was assumed for the review of the QA data for the 3-1/2 month period following the corrective action completed on 7/1/83. Relative to this value, two apparent exceedances of the + 2% opacity span drift limit were observed. On 7/9/83, a panel meter span response of 59% opacity was noted; however, the chart recorder span check response was 62% opacity for the same day. On 9/28/83, a chart recorder span response of 59% opacity was observed. This value is 1% opacity below the control limits, and indicates a low bias in the opacity monitoring data. Corrective action was not taken to resolve either of the above problems. Nevertheless, the span check values on each of the following days was within the span drift limit.

A comment included in the daily check log (6/6/83) raises concern with respect to the consistency of reading/recording panel meter and chart recorder responses: "Operators continue to misread panel meter and data recorder."

Time Required for Daily Checks

The time required to perform the daily checks of the Unit No. 5 opacity CEMS can be estimated from the daily log sheets. During the 7 months of implementation of the QA procedures, approximately 14 different individuals performed the daily checks on various occasions. Based on the log sheets, the time required to perform the daily checks during this period typically ranged between 1 and 7 minutes per day; however, on seven occasions, more than 10 minutes were required to complete the daily checks. Lake Road Station personnel offered the following clarification of the tabulated results:

> "The personnel responsible for completing these forms must account for their time and normally the smallest increment they report is 1/10 of an hour. This resulted in a great deal of 6 minutes or more time periods being reported. Although 1 minute is more typical of the time required to perform the daily checks."

6.3.2 Periodic QA Checks/Corrective Action

The periodic QA procedures provide for checks of monitoring system components and operational status that are unfeasible, impractical, or unnecessary on a daily basis. The periodic QA checks were intended to be performed in conjunction with routine maintenance activities for the opacity CEMS. At the beginning of the project, the periodic QA checks were scheduled to be performed monthly. The periodic QA check procedures included: (1) zero and span checks of the opacity monitor according to both the panel meter and the chart recorder, (2) a check of optical alignment of the transmissometer components, (3) a determination of the apparent dust accumulation on the optical surfaces, and (4) a check of the monitor calibration at 0% and 100% opacity using a zero jig.

The corrective action procedures and log were intended to provide a general indication of what was done to resolve specific monitor problems and to document the impact of adjustments/repairs on (1) fault lamp status, (2) zero and span check responses, and (3) monitor calibration. It was intended that a corrective action log would be completed on each occasion when control limits were exceeded in either the daily or the periodic QA checks and on all other occasions when adjustments or repairs of the opacity CEMS were performed.

Periodic QA check logs and/or corrective action logs were completed on six occasions between 6/30/83 and 4/20/84 for the field study that was conducted at Lake Road Unit No. 5. The data forms are included in Appendix D of this report. In each case, the same individual conducted the checks and completed the data forms. For five of the six occasions, both a periodic QA check log and a corrective action log were submitted. Most of the data forms contain numerous entries regarding specific electronic measurements and adjustments that were made. However, the impact of these adjustments on the overall performance of the opacity CEMS is often difficult or impossible to determine from the recorded data. The following is a summary of the periodic QA/corrective action activities that were performed:

6/30/83 - The dirty window fault indicator was activated. Electronic adjustments to the window status sensitivity circuitry were made to correct the fault conditions. The data sheet indicates that a circuit board affecting the window status sensitivity had been replaced on 6/24/83. No corrective action log for this repair was submitted with the other QA documentation.

A chart recorder zero check response of 4% opacity (which exceeds the ± 2% opacity zero drift limit) was noted on the daily log for 6/27/83 and was also noted in the periodic QA corrective action documentation. Electronic measurements indicated that the problem was not in the transceiver; subsequent efforts indicated the problem was in the linearizer/integrator board. Additional measurements were made; the manufacturer (Contraves Goerz) was called for advice; the problem was apparently resolved after additional adjustments recommended by the manufacturer were made.

8/24/83 - A periodic QA check was performed, apparently because the dirty window fault indicator was activiated. The QA log indicates that the windows were cleaned; however, both the effluent opacity measurements and the window status indicator remained unchanged. Electronic adjustments to the window status circuit and the transceiver meter were made. Filters were used to check the monitor calibration, and the QA log states "readings were satisfactory after slight adjustment of zero"; however, filter response data were not provided.

10/7/83 - Adjustments were made to calibrate the system and to correct the dirty window fault indicator that was activated on 10/6/83 according to the daily QA log. The chart recorder calibration was checked in both the "instantaneous" and "integrate" modes, and was found to be acceptable. A minor shift in the optical alignment was observed; however, the alignment was reported to be within acceptable limits, and no adjustments were performed.

10/13/83 - The reason station personnel conducted the periodic QA check/corrective action on this date is not clear from any of the QA records.

10/13/83 (cont'd) The QA documentation indicates that the power supply board was replaced because improper results were obtained during the most recent voltage checks (the dates of these checks are unknown). Voltage measurements were not made after the power supply board was replaced.

A gasket was found in the transceiver tube that was reportedly obstructing the light beam and biasing the monitoring results high by approximately 8% opacity. The gasket was removed.

The optical alignment of the transmissometer was found to be unacceptable. Adjustments were made to restore proper alignmeht.

Calibration checks of the transceiver meter, panel meter, and chart recorder were made at 0%, 18.1%, 52.0%, and 100% opacity using the Unit No. 5 zero jig and a set of neutral density filters. Zero and span checks were also performed, and the responses provided by all three data display devices were compared. Errors in the chart recorder responses ranged from 1% to 6% opacity. Adjustments were made to correct the chart recorder calibration.

1/5/84 - Notes in the QA documentation state, "Transmissometer totally inaccurate due to systems failure. Found faulty power supply. Replaced [power supply] and calibrated transmissometer."

4/20/84 - According to the QA documentation, a representative from Contraves Goerz (1) serviced the monitor, (2) performed a clear-path test in the shop, (3) replaced the timing diodes in the transceiver, (4) attempted to align the transceiver optics, (5) performed electronic adjustments, and (6) adjusted the dirty window indicator sensitivity. Station personnel and the Contraves representative reinstalled the monitor and completed final calibration checks. (The Contraves field service report also stated that, "Light source is slightly clipped at air nozzle.")

The repairs and adjustments performed by the Contraves representative were apparently not totally successful, according to the quarterly report submitted by St. Joseph Light and Power Company, Lake Road Station to the Missouri DNR for the second quarter of 1984. This report contains the following statement:

> "During the time period of April 16th through the 19th, the opacity monitors on both Units 5 and 6 were inspected and calibrated by a Contraves Service Repairman. This was a routine inspection. During this inspection a problem with the optical alignment on the opacity monitor on Unit 5 was discovered. An attempt was made to align the optics in the field, but could not be performed to the Service Repairman's requirements. His suggestion was that the unit be sent back to the factory for repair.

> On May 17th, the monitor was removed and sent back to the factory. Due to damage occurred [sic] during shipment and some unexplained delays, the unit was returned on June 27th and installed in the stack on July 2nd. Since this time, the monitor has had no other maintenance problems."

6.4 SOURCE SELF AUDIT

Personnel at the Lake Road Station conducted a performance audit of the Unit No. 5 opacity CEMS on July 23, 1984 using audit devices supplied by the project team. Source personnel had previously observed and/or participated in the initial audit, had access to the detailed report for the initial audit, and were furnished a copy of "Performance Audit Procedures for Opacity Monitors" (EPA-340/1-83-010). Using this information, the Lake Road Station personnel conducted the performance audit generally in accordance with the prescribed procedures and completed the necessary data sheets (see Appendix D). The results that were calculated from the data provided by the source self audit are summarized in Table 6-2 for the Unit No. 5 CEMS.

The results of the source self audit show that the Unit No. 5 opacity CEMS met all of the audit criteria except for high range calibration error.

The apparent failure of the opacity CEMS to meet the calibration error limit for the high range test is believed to be due to a reporting error, and is not considered to be representative of actual monitor performance. This situation occurred because an administrative error was made when the audit filters were transmitted the to Lake Road Station. The value of the high range filter provided to the Lake Road Station personnel for use in the self audit was 42% opacity. This value was incorrect; the correct value of the high range filter was 46% opacity, as is indicated by filter calibration data obtained prior to and after the audit. The monitor responses for the high range calibration error tests reported by the Lake Road personnel for the self audit were exactly equal to the incorrect filter value (i.e., 42% opacity) for five consecutive measurements. It should be noted that the high range calibration error test results for the self audit are not supported by the results of the final audit that was conducted less than three weeks later (see Section 6.5 below).

6.5 FINAL PERFORMANCE AUDIT

A final performance audit of the Lake Road Station Unit No. 5 opacity CEMS was conducted on August 16, 1984. This audit marked the end of the 1-year field study at the Lake Road Station. Detailed discussions of the findings and results of the final audit are included in the August 1984 audit report for this station.

The results of the final performance audit of the Unit No. 5 opacity CEMS are summarized in Table 6-3. The following conclusions were derived from the results of the final performance audit:

TABLE 6-2. SUMMARY OF PERFORMANCE AUDIT RESULTS
ST. JOSEPH LIGHT AND POWER COMPANY, LAKE ROAD, UNIT NO. 5
CONTRAVES GOERZ MODEL 400 OPACITY MONITORING SYSTEM
- SOURCE SELF AUDIT -

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Dirty Window	On*	Off
Stack Power	On	On
Stack Exit Correlation Error	0%	± 2%
Panel Meter Correction Factor	1.0	0.98 to 1.02
Transceiver Meter Correction Factor	1.02	0.98 to 1.02
Internal Zero Error	+1.0% Opacity	± 2% Opacity
Internal Span Error	-0.5% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	0.0% Opacity	≤ 2% Opacity
Reflector Window	0.0% Opacity	≤ 2% Opacity
Total	0.0% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS

	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (9.0% Opacity)	-0.4%	0.7%	1.1%	≤ 3%
Mid Range (21.0% Opacity)	0.4%	0.6%	1.0%	≤ 3%
High Range (46.0% Opacity)**	-4.0%	0.0%	4.0%	≤ 3%

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[*] Plant personnel indicated that an electrical short circuit caused this fault lamp to be illuminated. Plant personnel had not been able to locate the problem but were aware that the dirty window indicator was defective.

[**] The high range calibration error test result is believed to be due to a reporting error and is not considered to be representative of actual monitor performance.

TABLE 6-3. SUMMARY OF FINAL PERFORMANCE AUDIT RESULTS
ST. JOSEPH LIGHT AND POWER COMPANY, LAKE ROAD, UNIT NO. 5
CONTRAVES GOERZ MODEL 400 OPACITY MONITORING SYSTEM

MONITOR COMPONENT ANALYSIS	Audit Result	Acceptable Result
Fault Indicator Lamps:		
Dirty Window	On*	Off
Stack Power	On	On
Stack Exit Correlation Error	0%	± 2%
Transceiver Meter Correction Factor	0.98	0.98 to 1.02
Internal Zero Error	0.0% Opacity	± 2% Opacity
Internal Span Error	0.5% Opacity	± 2% Opacity
MONITOR MAINTENANCE ANALYSIS		
Monitor Alignment (Centered)	Yes	Yes
Optical Surface Dust Accumulation:		
Transceiver Window	1.0% Opacity	≤ 2% Opacity
Reflector Window	2.0% Opacity	≤ 2% Opacity
Total	3.0% Opacity	≤ 4% Opacity

CALIBRATION ERROR ANALYSIS	Mean Error (Opacity)	Confidence Interval (Opacity)	Calibration Error (Opacity)	Acceptable Calibration Error (Opacity)
Low Range (11.3% Opacity)				
Transceiver Meter	-1.0%	0.2%	1.2%	≤ 3%
Strip Chart	-0.9%	0.7%	1.6%	
Mid Range (19.6% Opacity)				
Transceiver Meter	-1.2%	0.5%	1.7%	≤ 3%
Strip Chart	-0.6%	0.0%	0.6%	
High Range (31.4% Opacity)				
Transceiver Meter	-1.4%	0.1%	1.5%	≤ 3%
Strip Chart	-1.0%	0.7%	1.7%	

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*Plant personnel indicated that an electrical short circuit caused this fault lamp to be illuminated. Plant personnel had not been able to locate the problem but were aware that the dirty window indicator was defective.

1. The Unit No. 5 opacity monitoring system exhibited acceptable performance for all of the criteria evaluated during the August 1984 performance audit.

2. The dirty window fault indicator was malfunctioning during the audit; the levels of dust accumulation on the transceiver and reflector optics were within acceptable limits.

3. Both the strip chart recorder and the transceiver meter provided accurate and precise measurements, as indicated by the calibration error results. In addition, the outputs provided by the two data display devices were very consistent during the audit.

6.6 CEMS DOWNTIME

Figure 6-3 illustrates the total CEMS downtime for the Lake Road Station, Unit No. 5, as reported in excess emission reports from the first quarter of 1980 through the second quarter of 1984. The data for 1980 through 1982 were obtained from summaries prepared by the Missouri DNR; however, no information was available for many of the quarters. The CEM downtime data for 1983 and 1984 were obtained from a detailed review of quarterly reports submitted by St. Joseph Light and Power Company to the Missouri DNR. (See " An Analysis of Opacity CEMS Downtime in Excess Emission Reports: Opacity CEM Pilot Project," May 1986, for additional discussions and comparative results for other sources.)

As can be seen from Figure 6-3, CEMS downtime for Unit No. 5 was highly variable. The CEMS downtime decreased from an initial value of approximately 78% to a value of less than 1% for the first two reporting periods, varied significantly during the pilot project field study, and eventually rose to a value of approximately 50% for the second quarter of 1984, when the monitor was returned to the manufacturer for repairs. With the exception of the second quarter of 1984, the vast majority of the reported CEMS downtime was due to problems with (1) the strip chart recorder drive (it often ran slow or not at all), and (2) the 6-minute integration circuit of the monitor. Thus, the transmissometer portion of the CEMS achieved high levels of monitor availability; however, the data averaging and recording mechanisms did not.

The daily QA check log and instructions provided a blank for the recording of the hours of monitor downtime during the 24-hour period preceding each daily check. The monitor operators recorded only those periods when the transmissometer was inoperative and ignored the downtime associated with the averaging and recording mechanisms of the CEMS. Thus, the CEMS downtime recorded in the daily logs completed during the field study is only a small fraction of the CEMS downtime reported to the Missouri DNR in quarterly excess emission reports. This result supports the CEMS availability findings based on the information contained in the reports submitted to the Missouri DNR.

6.7 CONCLUSIONS

The following conclusions are based on the evaluation of the results obtained from performance audits and implementation of quality assurance procedures for the Contraves Goerz Model 400 opacity CEMS installed at St. Joseph Light and Power Company's Lake Road Station, Unit No. 5.

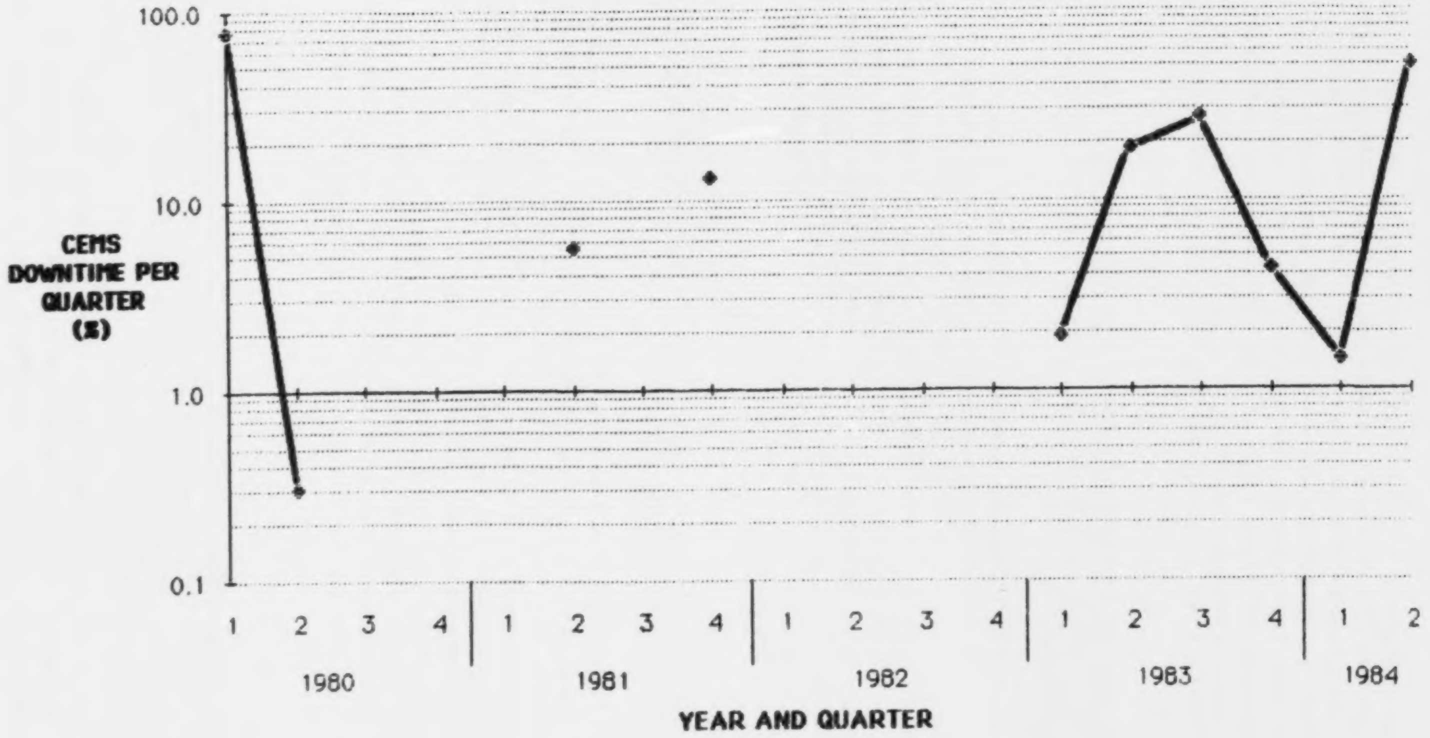

FIGURE 6-3. CEMS DOWNTIME - ST. JOSEPH LIGHT AND POWER COMPANY, LAKE ROAD UNIT NO. 5

1. The Contraves Goerz opacity CEMS installed at Lake Road Unit No. 5 did not achieve consistently high levels of availability during the study. CEM downtime varied greatly and significantly exceeded 10% for three reporting periods.

   (CEMS downtime was approximately 20% for the second quarter of 1983 (i.e., the beginning of the field study), increased to approximately 28% for the next quarter, decreased to less than 5% for the next two quarters, and then increased to approximately 50% for the second quarter of 1984, when the monitor was returned to the manufacturer for repairs. Prior to the second quarter of 1984, most of the CEMS downtime was due to problems with the chart recorder drive and/or with the 6-minute integrator circuit, rather than to problems with the actual transmissometer.)

2. The accuracy and precision of the opacity CEMS data were within ± 4% opacity relative to the correct values for the daily zero and span checks during a period of 7 months.

   (Only one exceedance of the ± 2% opacity zero check control limit occurred based on the chart recorder responses. However, confusing notations in the daily logs and the lack of a zero offset relative to the mechanical limit of the chart recorder prohibited accurate quantification of negative zero drift. Only two exceedances of the ± 2% opacity span check control limit occurred. However, the assigned span value changed from 64% opacity to 62% opacity midway through the 7-month period, apparently as a result of adjustments performed on 6/30 - 7/1/83 during a periodic QA check/corrective action.)

3. The accuracy of the opacity CEMS data significantly improved as a result of the repairs performed by the manufacturer.

   (At the beginning of the study, the accuracy of the opacity CEMS data was within 4% opacity as indicated by the calibration error check results for the initial performance audit. However, because of uncertainty regarding the status of the zero alignment and because of the 2% opacity span value shift that subsequently occurred, it may only be assumed that the actual accuracy of the opacity CEMS data was within ± 6% opacity. Following the repairs performed at the manufacturer's facility and the reinstallation of the opacity monitor (which included a zero alignment check), the accuracy of the opacity CEMS data was within ± 2% opacity as indicated by the calibration checks conducted during the source self-audit and the final audit.)

4. For the Lake Road Unit No. 5 CEMS, either the WINDOW fault system is not an accurate indicator of the dust accumulation on the transceiver window, or the purge air system does not adequately protect the exposed optical surface of the transceiver from contamination.

   (During the first 7 months of the study, there were at least eight occasions, totalling at least 16 days, when the WINDOW fault indicator was activated. This very high frequency of WINDOW faults shows that either the fault indicator is defective, or that the transceiver windows are rapidly contaminated (possibly from particulate matter emitted by the stream vent on the ash handling system). The quantity of dust accumulated on the optical surfaces could not be determined from the periodic QA checks. The WINDOW fault circuit was malfunctioning due to an electronic short circuit that occurred before and during the final audit (i.e., after monitor repairs were made by the manufacturer). However, it is not possible to determine whether the initially observed problems were related to the short circuit observed before and during the final audit.)

5. The periodic QA check and corrective action documentation for the Lake Road Unit No. 5 opacity CEMS does not provide sufficient information to determine whether the monitor was operating properly.

   (The periodic QA checks were scheduled to be performed on a monthly basis, but were instead usually performed in conjunction with corrective action activities. Only six periodic QA checks/corrective actions were performed by station personnel during the 1-year study. In many cases, (1) the dust accumulation on the optical surfaces, (2) the effects of zero or span adjustments, or (3) the effects of various repairs that were made were impossible to quantify because of the nature of the monitoring problems that occurred (i.e., off-scale monitor responses, power supply failures, etc.) and because of the manner in which the QA documentation was completed. For some cases, the reported information is not adequate to determine if the opacity CEMS was operating within applicable control limits after corrective action was completed.)